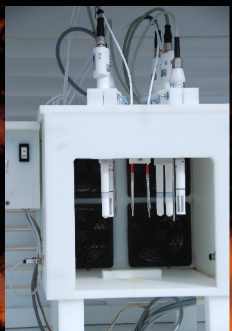
ALVICE during MOHAVE2009

Atmospheric Lidar for Validation, Interagency Collaboration and Education

D. N. Whiteman, NASA/GSFC
D. D. Venable, Howard University
M. Cadirola, Ecotronics, LLC
K. Vermeesch, SSAI
M. Calhoun, Howard University
G. McIntire, SGT



Acknowledgments: Atmospheric Composition Program, ESTO/IIP, UCAR, Larry

Why I missed the first workshop ...

- Stephanie, age 8, during SnowMaggedon part I. Part II brought an additional 8 – 10 inches .... Total accumulation of ~26” - 30” (~0.7 m).

Overview

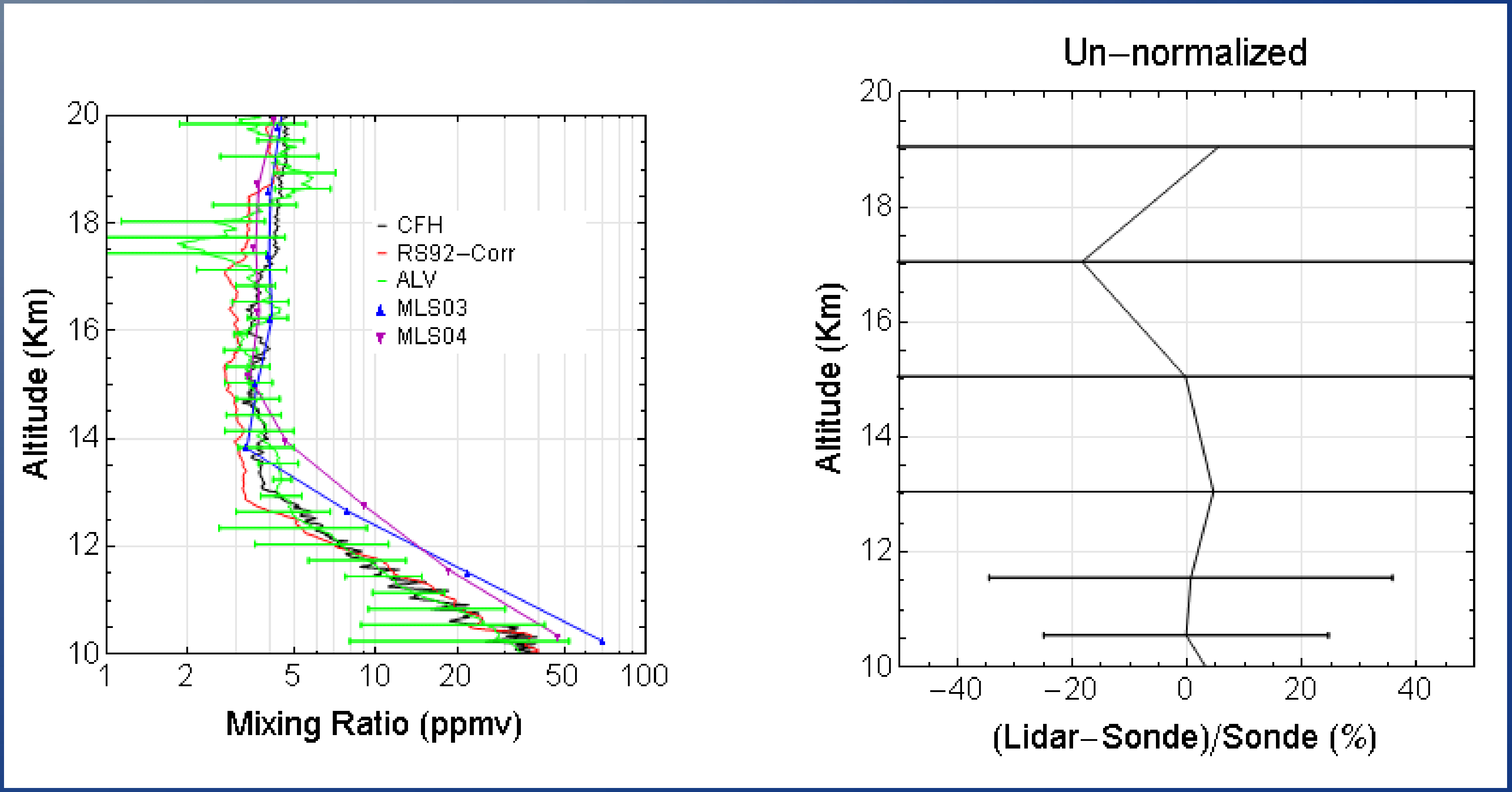
- ALVICE deployed for MOHAVE2009 with extra instrumentation to simulate a stand-alone cal/val configuration for NDACC.
  - ALVICE lidar (water vapor, temperature, aerosols, clouds)
    - 17.5 W @ 355nm, 0.6m telescope, 0.25, 0.1 nm filters, 0.25 mrad fov (JTECH – Nov, 2010)
  - RS92
    - Miloshevich corrections
  - CFH (Imet version)
    - Bad pre-amp
  - SuomiNet GPS total column water (UCAR)
  - THRef system (brought by Larry but now incorporated into ALVICE)
    - P sensor now incorporated into datastream
- Lessons learned: More space and time needed to set up all instruments

Overview - II

- After setup with attendant repairs and adjustments, 88 hours of measurements on 13 nights during period Oct 12 – 27
- MOHAVE2009 characterized by warmer conditions than in 2007
  - Large number of insects attracted to UV beam during measurements of Oct 15 and 16 (we send our beam up in the middle of the telescope to improve overlap – worst situation for getting bugs in the telescope)
    - Damage to laser and telescope on those evenings
  - Transmission window that completely covers the telescope installed on Oct 17
    - Starphire glass has some UV absorption but N-WAVES_2009 results did not show evidence of fluorescence in water vapor retrievals

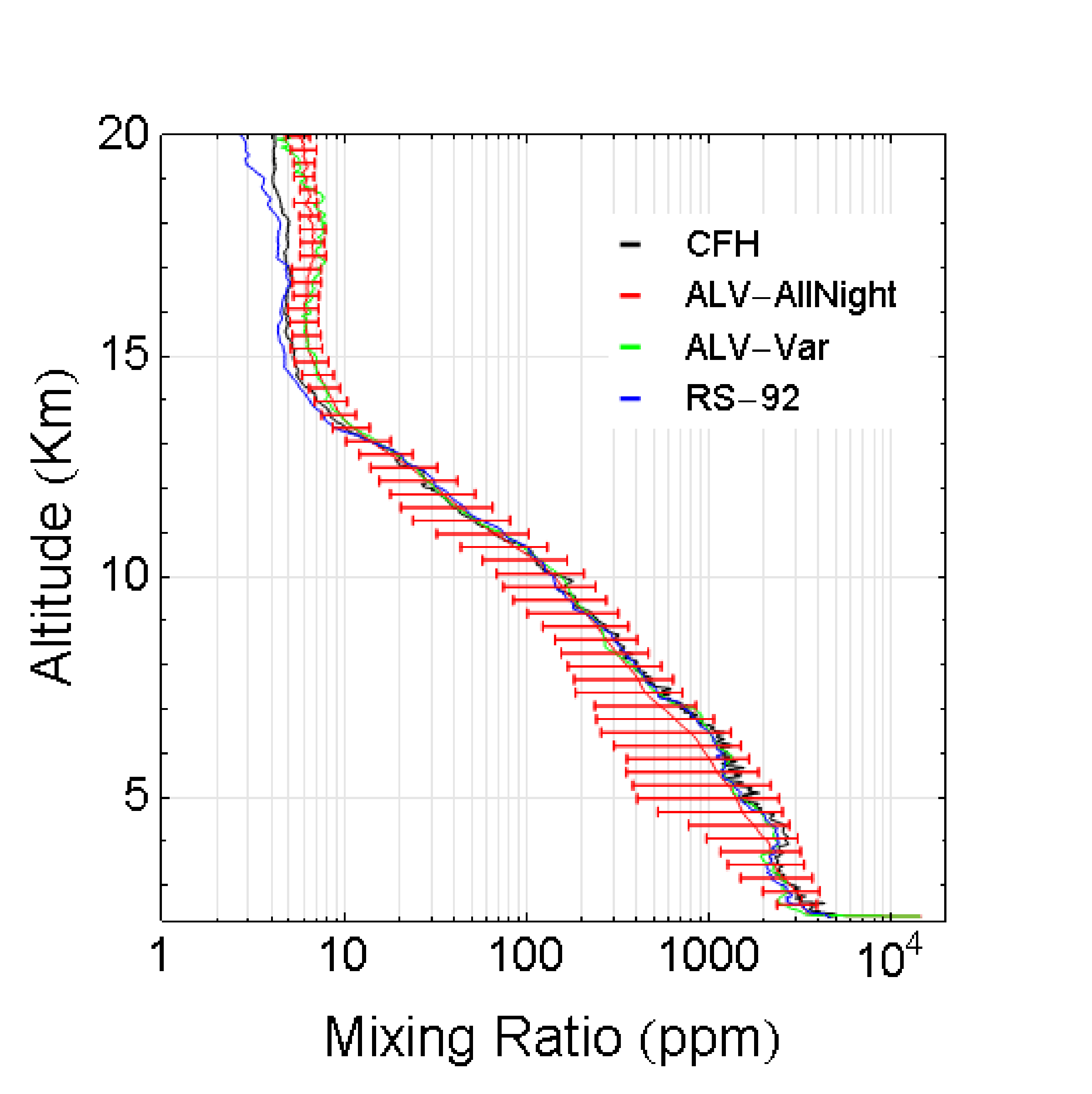
N-WAVES_2009

- March – April, 2009 Beltsville, MD. Surface elevation ~ 0.2 km. Average of 4 CFH (old version) comparison.
  - Noisier data than from TMF (2.3 km) but good mean agreement in the LS (note ~13 km trop height) with H_2O values ~4 ppm with Starphire window in place.



Prior to Boulder workshop ...

- ALVICE quicklook all night lidar averages from 9 nights versus CFHs on those nights (flip between slides to see with and without 1.5 PPM H2O subtraction in entire profile). But Is this correction justified?



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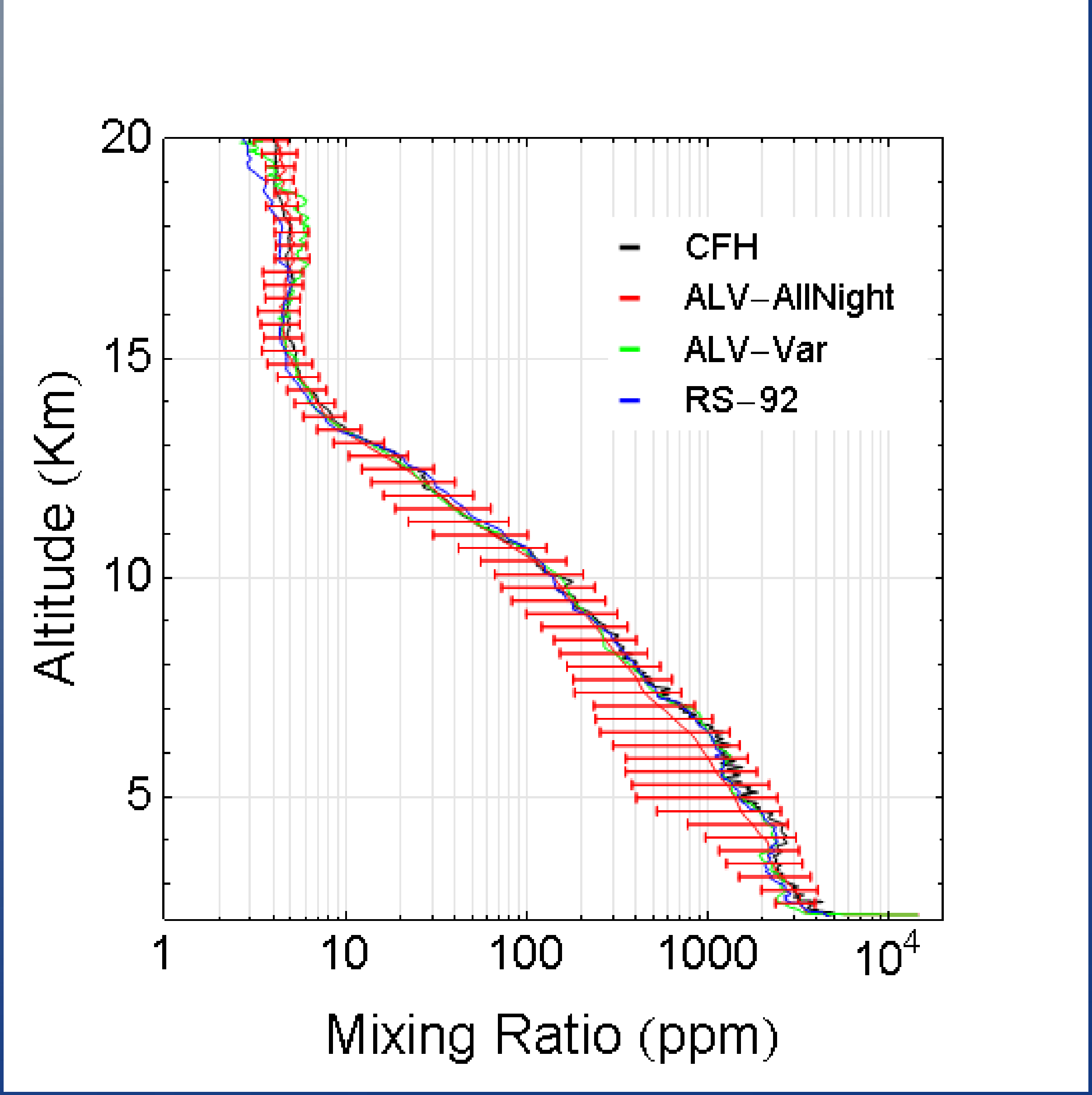


Analysis Since Boulder Workshop

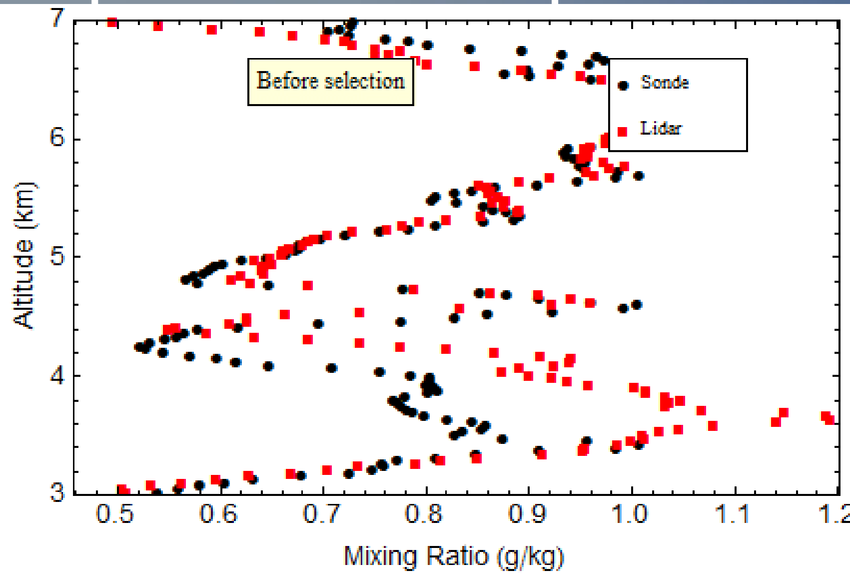
- Water vapor data completely reprocessed (v1.0,1.1)
  - T0 offset issues corrected
  - Temperature dependence of Raman scattering accounted for
  - Rayleigh and Mie corrections to transmission function
  - Adaptive radiosonde calibration function developed and tested
    - Single calibration constant for entire campaign
    - Lamp results considered
  - Overlap and fluorescence corrections derived and implemented
- Temperature analysis begun but not yet complete
- Examples of cloud retrievals
- Atmospheric aerosol fluorescence study yet to come

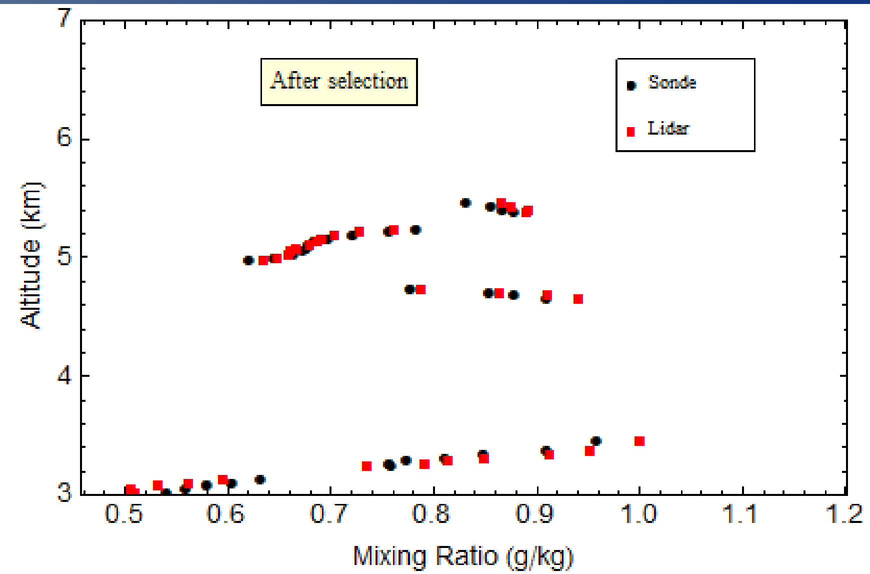
Adaptive radiosonde cal routine

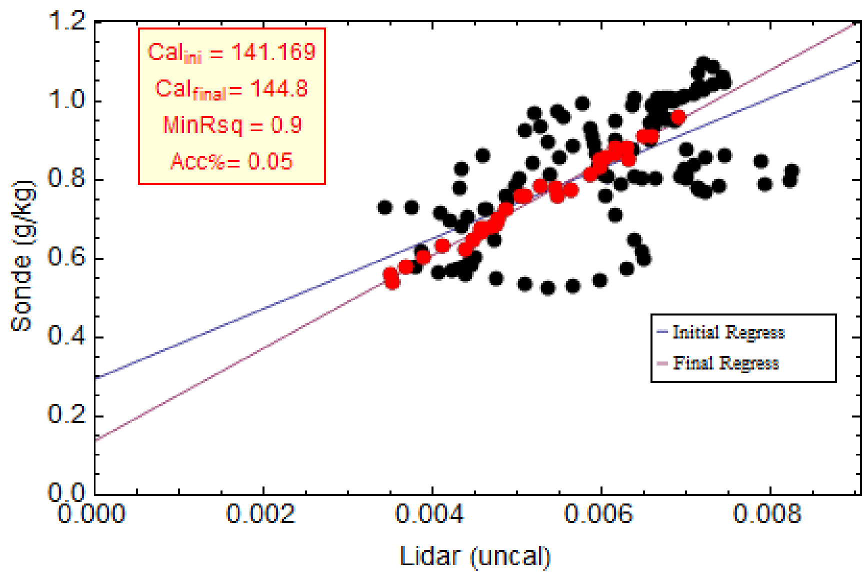
- Algorithm
  - User specified height range. Interpolate both datasets at higher resolution and create ordered pairs. Perform least square regressions over specified interval (0.5km) moving one point at a time. Select points where regressions conform to user specified Rsquare criteria. Eliminate duplicate points. Perform least median square regression and accept points within user specified percentage of the model prediction. Increase acceptance intervals if insufficient regression points are found. Final cal is the mean ratio of the accepted datapoints.
  - Routine is objective and removes need to selectively set the calibration interval. Aberrant cases require increased acceptance intervals to permit filtering of results.

Good case 20091021_0330

- The routine selects a linear set of points from a confusing ensemble. Goal is to have 1 km of order pairs. Min Rsq=0.9 at end of routine.

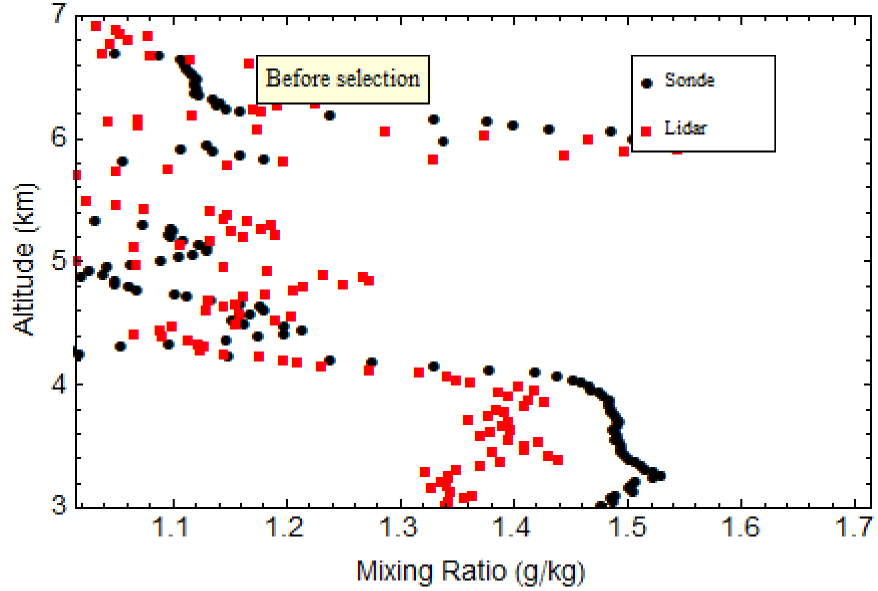


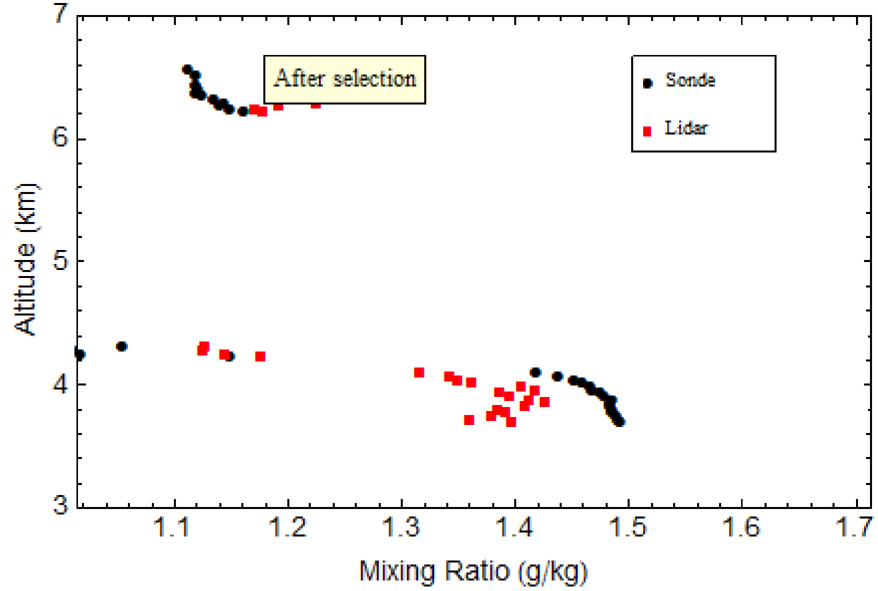


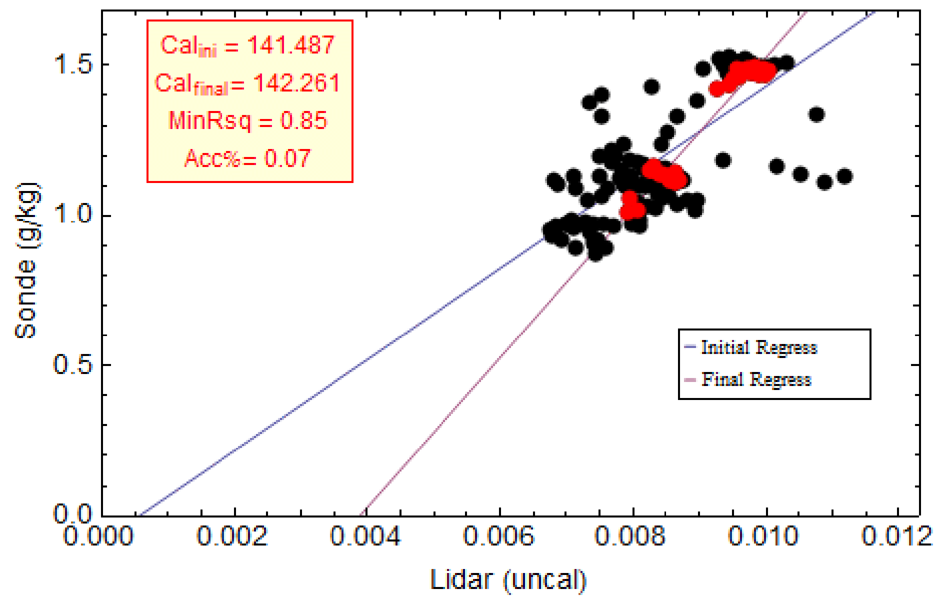


Bad case: 20091019_0331

- Incoherence in atmosphere features removes linear relationship between radiosonde and lidar measurements. Min Rsq=0.85 at end of routine.

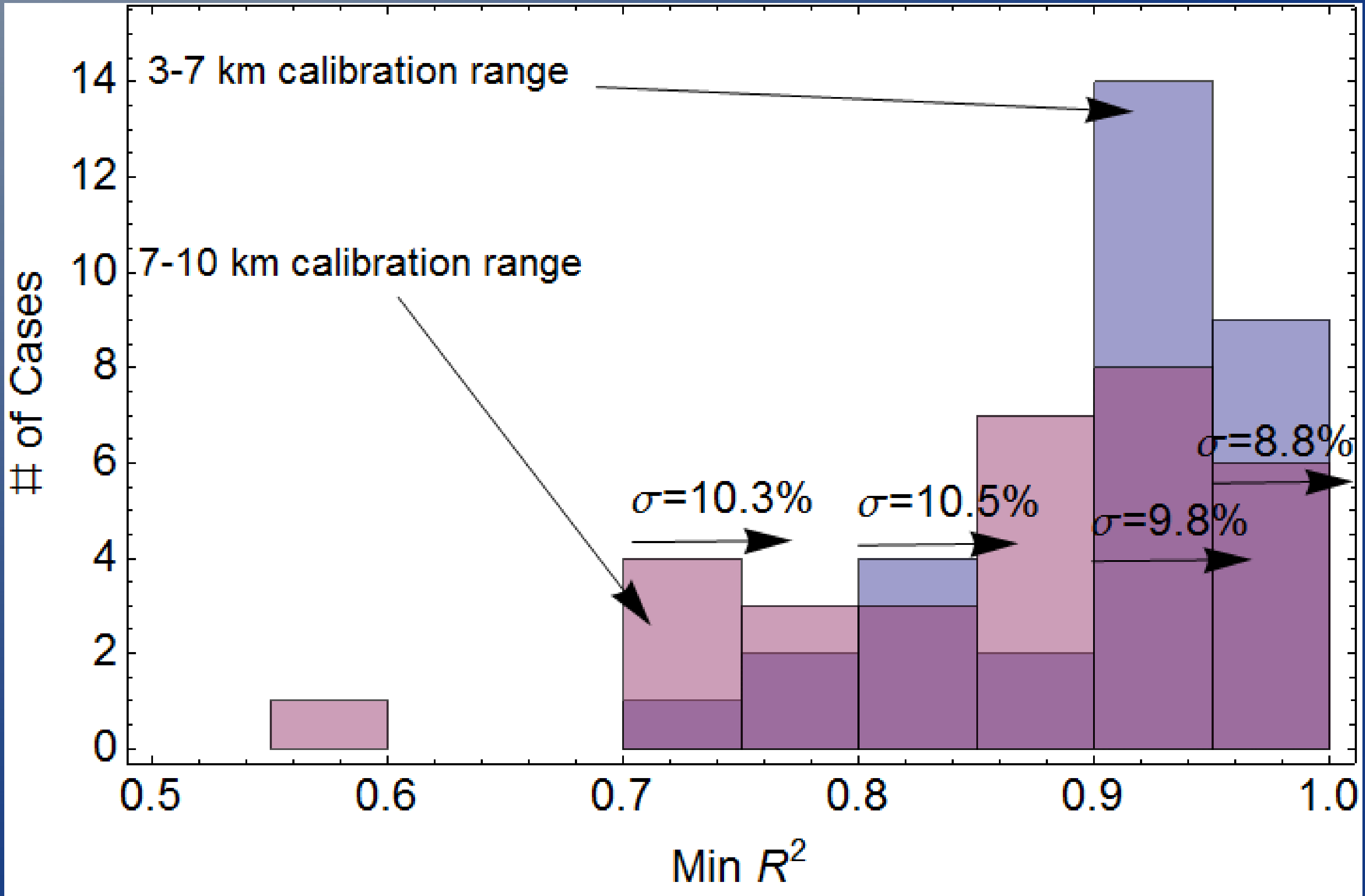






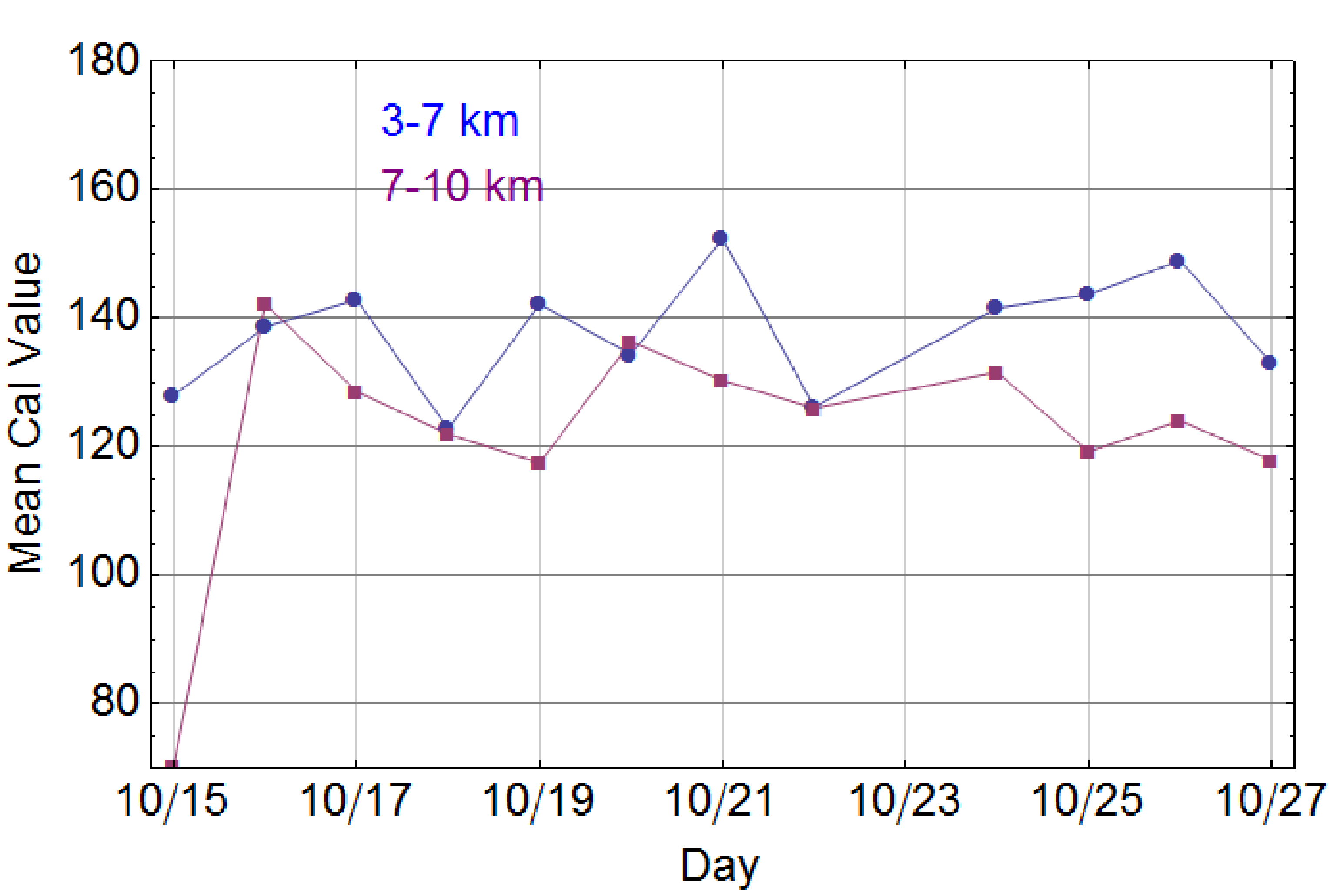
Min Rsquared as function of altitude window

- Larger number of cases with Rsq>0.9 in region 3-7 km
- Atmospheric variability appears to have more influence between 7-10 km than 3-7 km
- Calibration variance decreases as Min Rsq increases



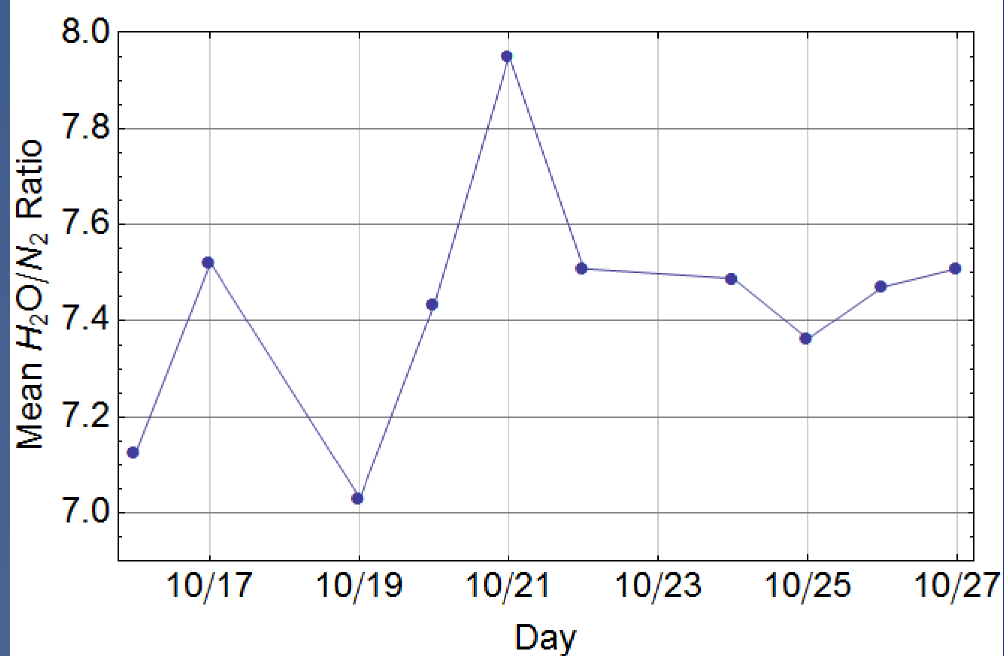
Final comparison of 3-7 and 7-10 km

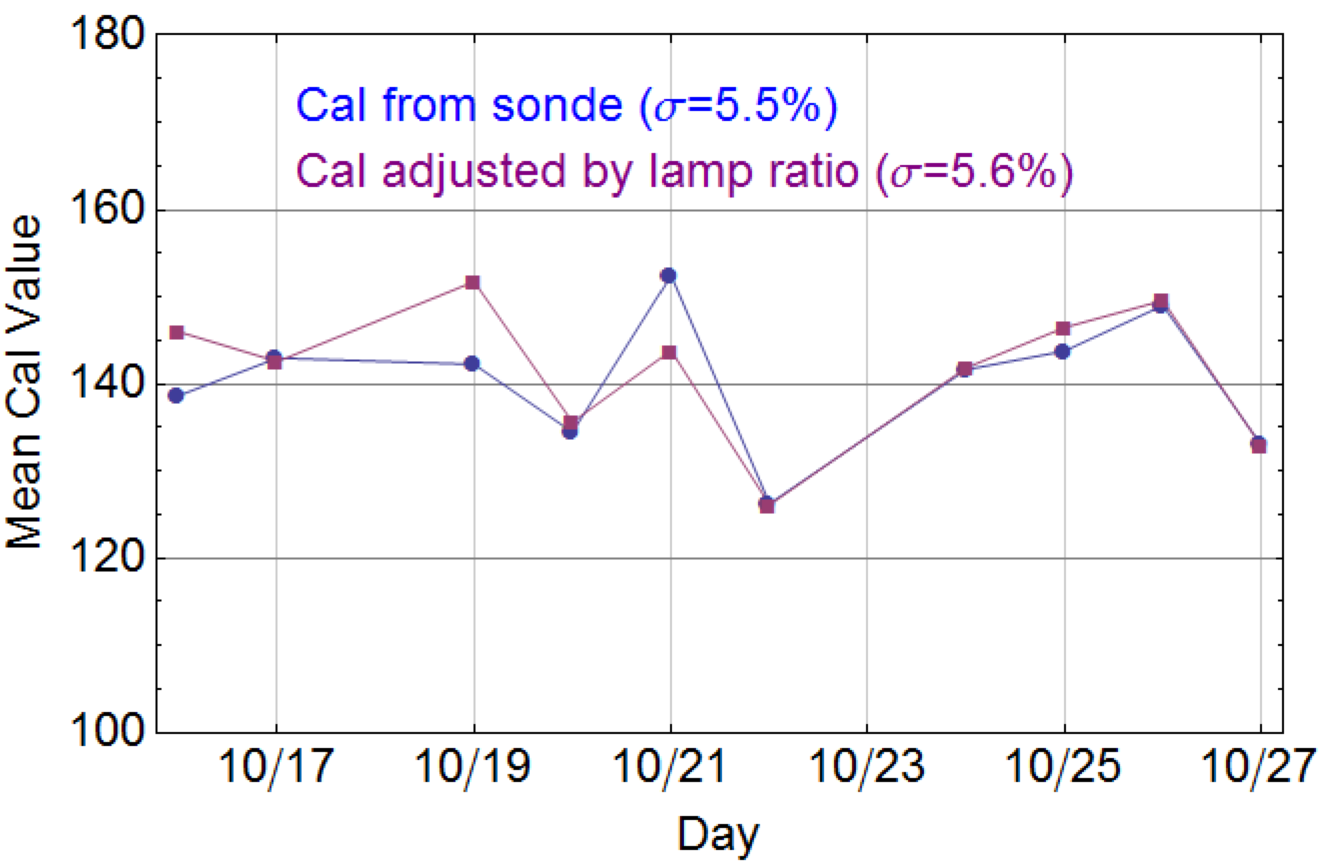
- Calibration determined between 7-10 km consistently lower than between 3-7 km using Larry's corrected sondes (?).



Lamp Adjustments to Calibration

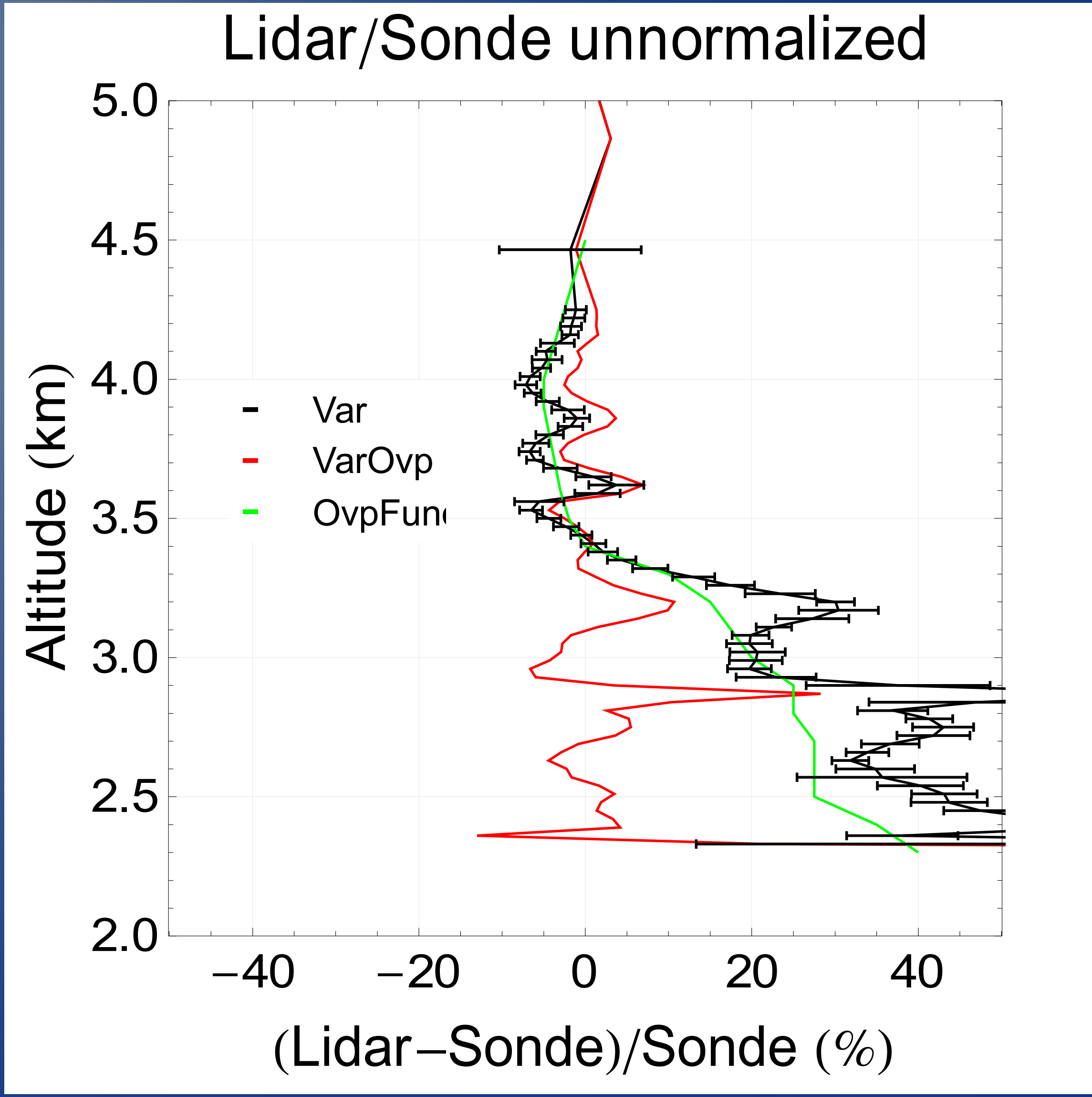
- Lamp runs made on all but 2 nights
- Did not improve the standard deviation of the calibration
- Implementation of full aperture lamp scanning underway in ALVICE





Overlap Correction for Water Vapor Mixing Ratio

- Overlap correction determined from hand selected set of “good” sondes
- Applied mostly in bottom 1.0 km. Small correction between 1 - 2 km (range).
- Correction will be “checked” during upcoming NWAVES_2011 campaign at HUBC



Fluorescence Corrected Equations

- Assume fluorescence influences water vapor but not N_2 significantly then ratio of signals used to calculate mixing ratio looks like

$$\frac{P(\Delta\lambda_{H},r)+\zeta P(\Delta\lambda_{R},r)}{P(\Delta\lambda_{N},r)}$$

- With this starting form, exact solution for mixing ratio becomes

$$w = w^{*}\frac{P(\lambda_{H},r)}{P(\lambda_{H},r)+\zeta P(\lambda_{R},r)}$$

- Assuming small corrections, approximate solution is

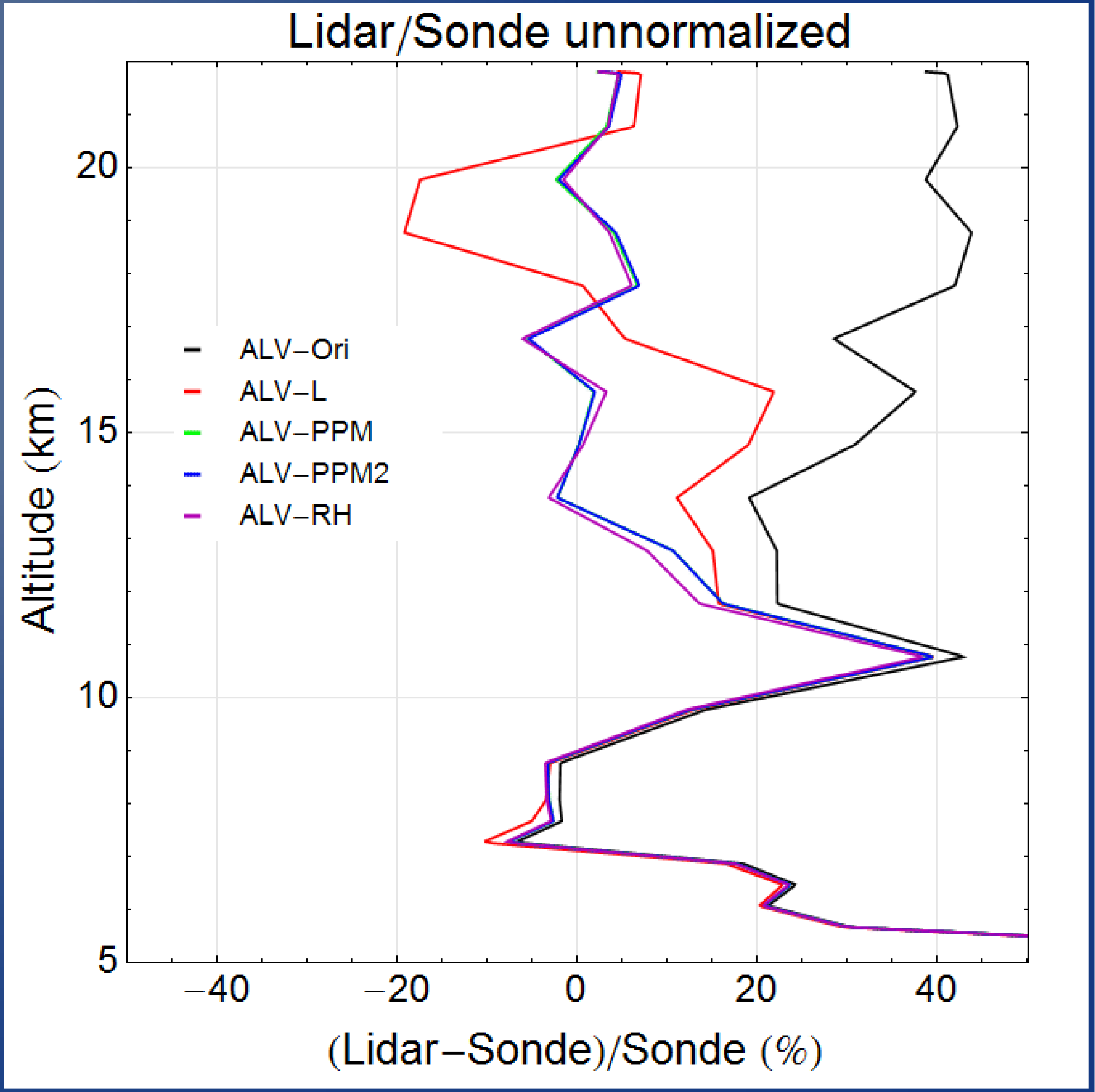
$$w = w^{*} - 2\zeta^{'}\Delta\tau(\lambda_{R},\lambda_{H},r)$$

- Random Error in fluorescence corrected data calculated as follows

$$\sigma = \sigma^{*}\sqrt{\frac{w^{*}-\alpha}{w^{*}}}$$

Compare Different Fluorescence decontamination techniques

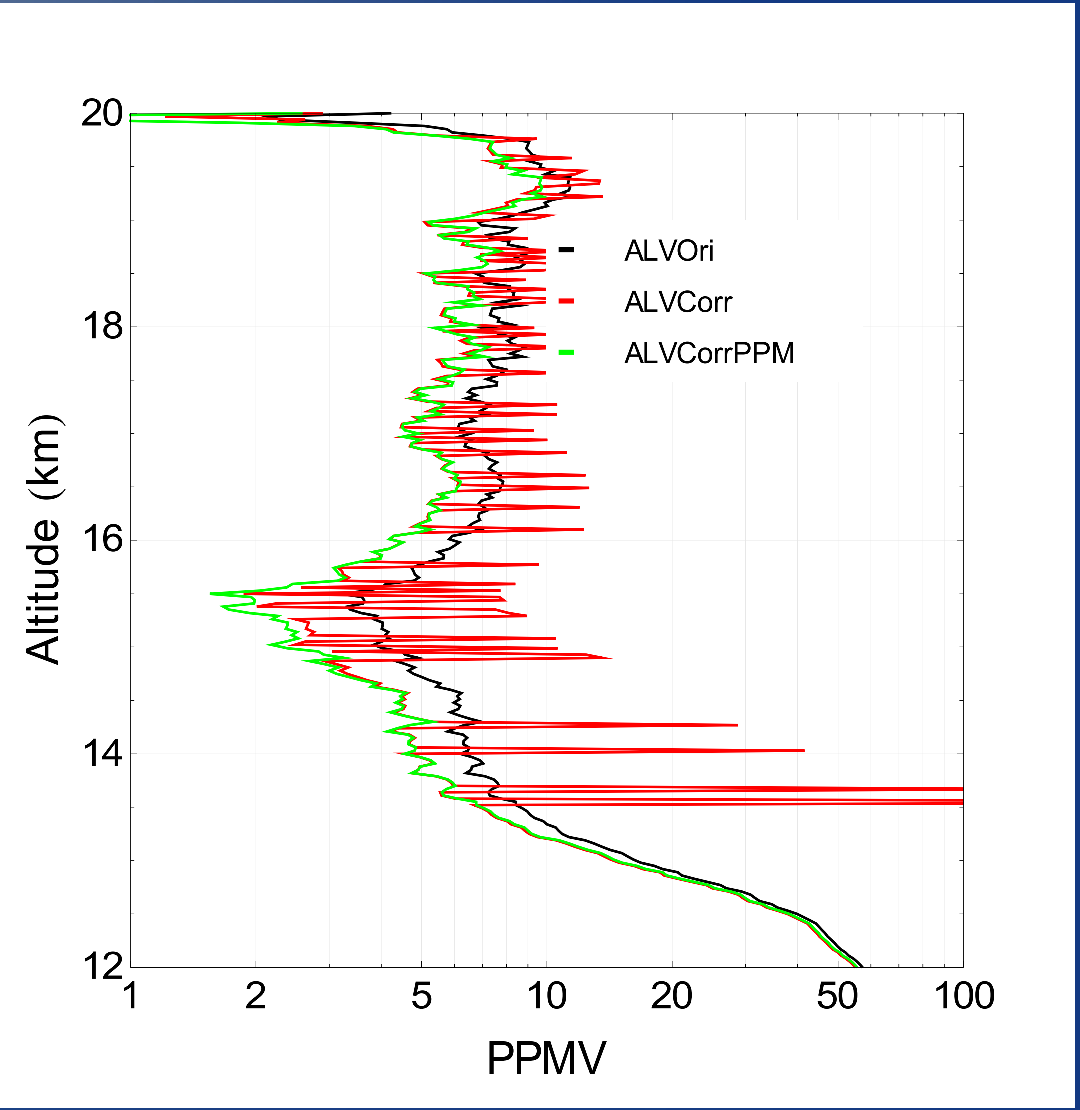
- Uses v0.9 “All Night” data for testing
- Correction methods
  - Liquid water channel subtraction
  - PPM1 = constant
  - PPM2 = constant*DT
  - Exact solution
- Agreement within few percent except for liquid channel



NB: CFH data not smoothed to lidar resolution for this comparison

Compare Different Fluorescence contamination techniques - II

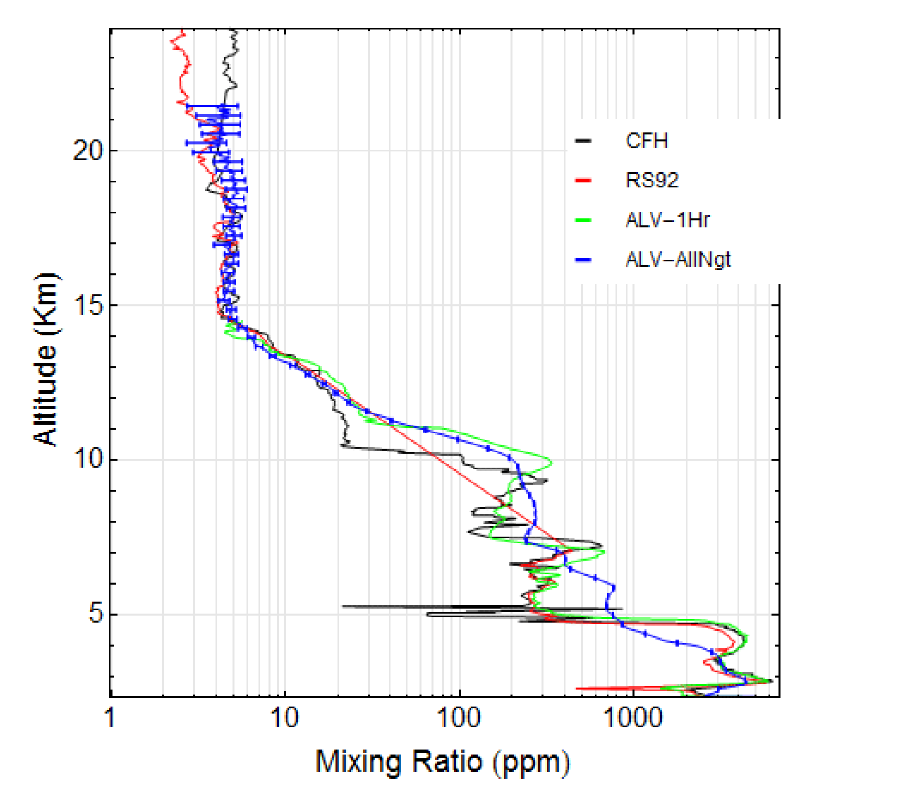
- But … In the inspection of the correction applied to hourly data, the correction is sometimes unstable when data get noisier
- So …For ease of implementation and robustness of correction, it is preferred to use the ppm DTH2O subtraction which gives essentially equivalent results in the LS to the exact solution performed under high S/N conditions (see previous slide).



1026_0559

ALVICE v1.1 vs RS92, (CFH+FPH)

- Smoothing filter prevents capturing some features (see layer between 10-12).
- Data should be compared either all smoothed with the same filter or all raw and compared in vertical layers



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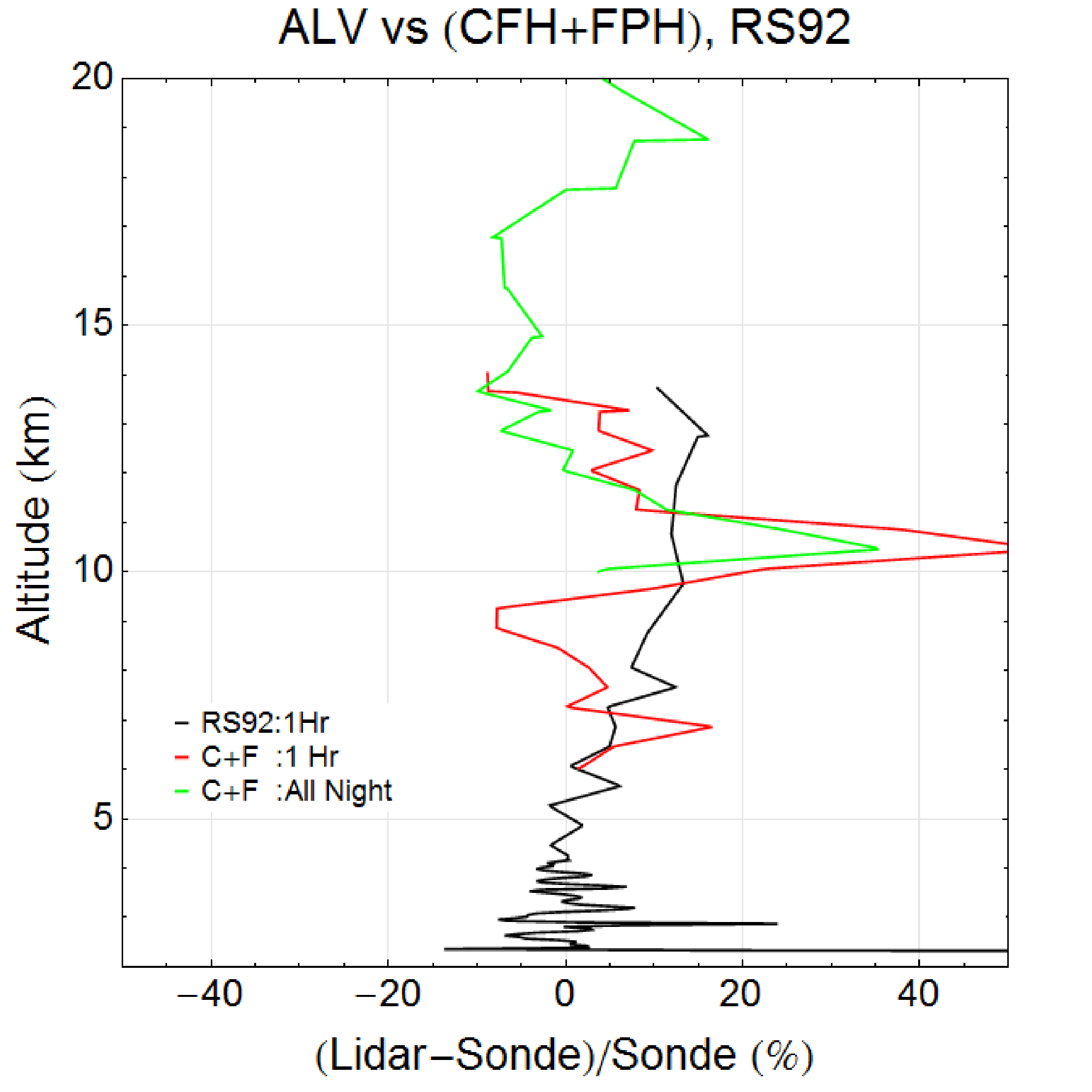
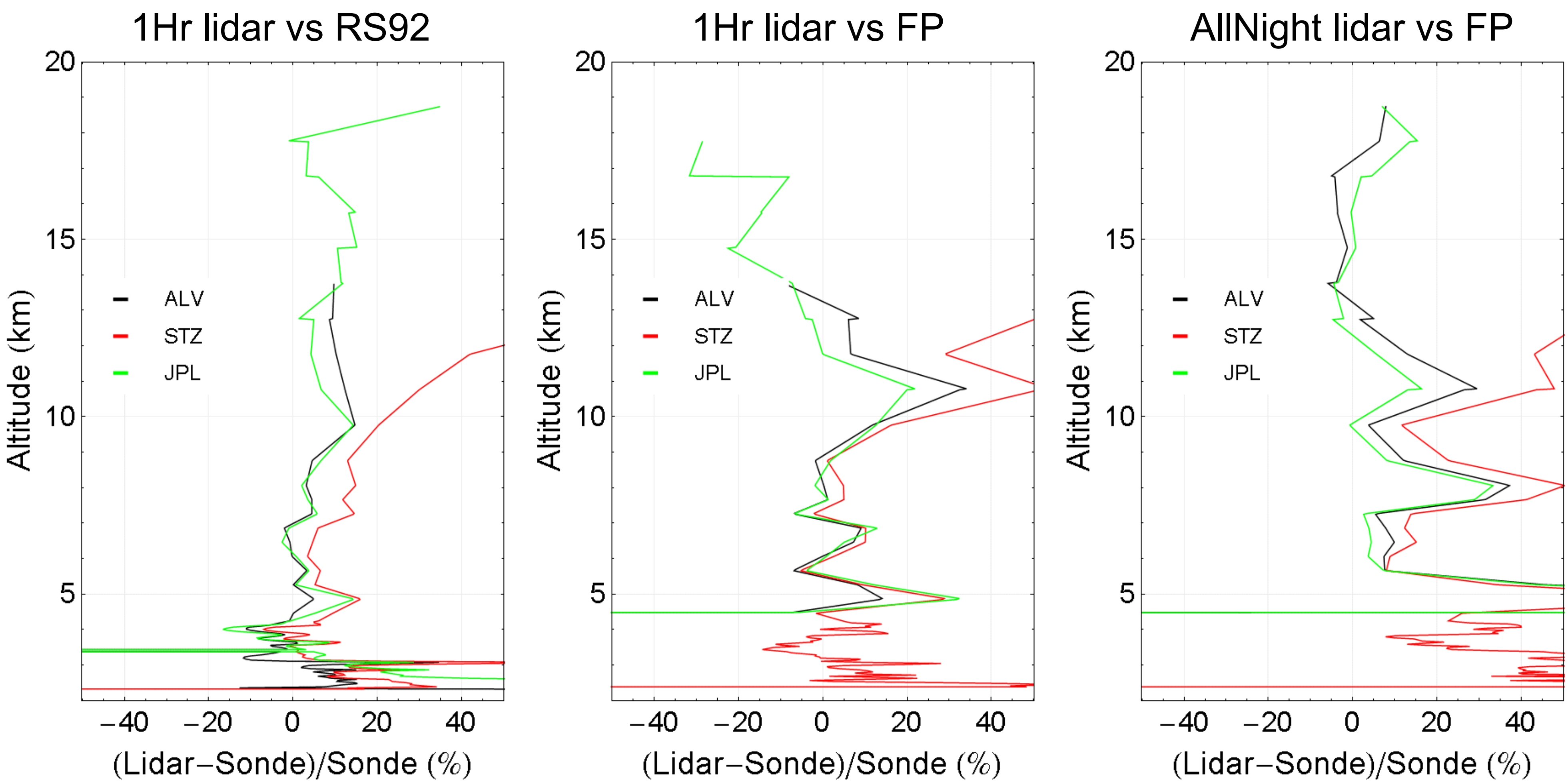


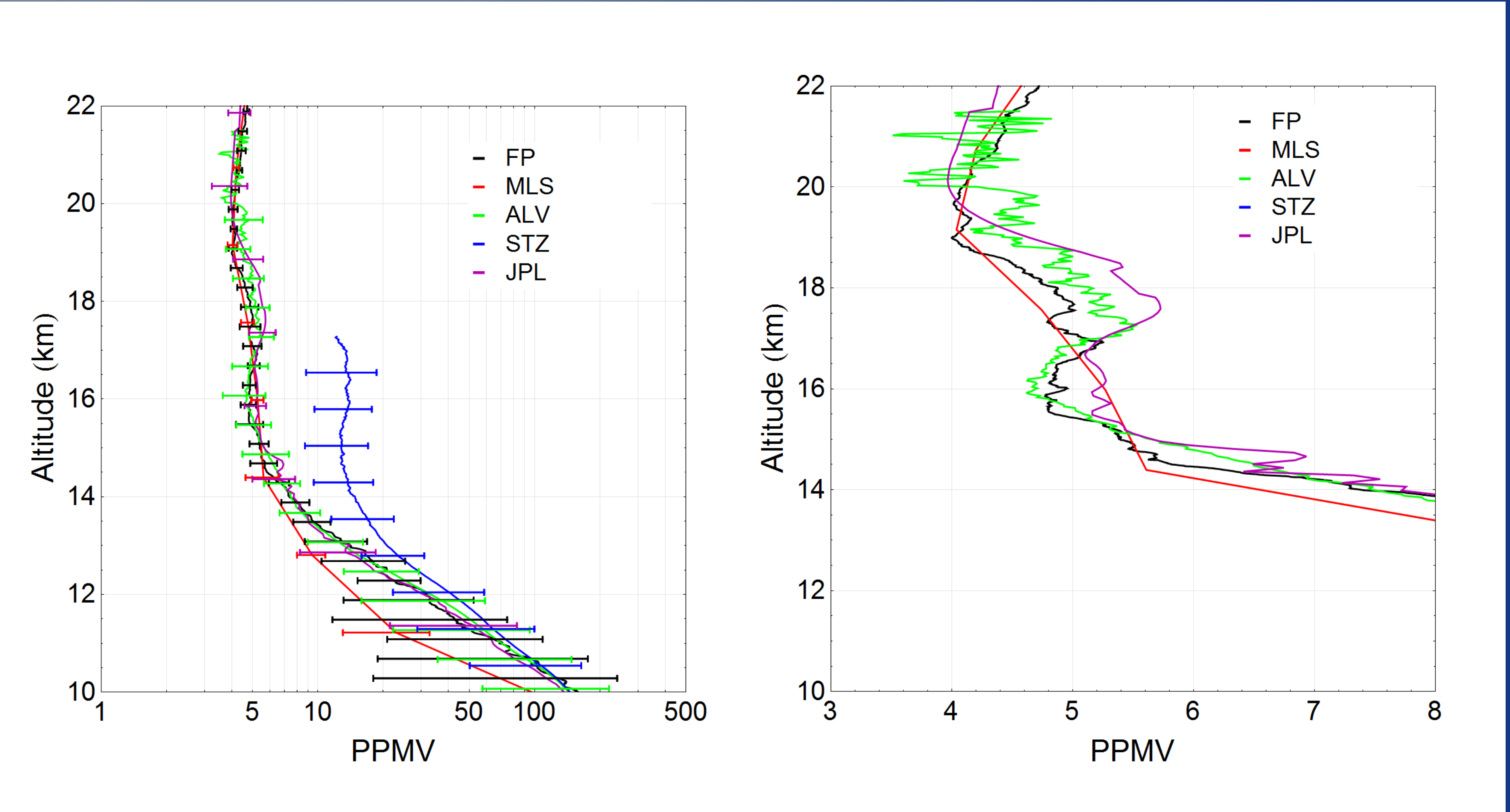
All Lidar vs RS92, FP – PPMV

- Taking composite of these 3 comparisons yields agreement of FP, JPL, ALV within ~10% above boundary layer and outside of regions of rapid transients
- BUT...comparisons need to be done at common resolution!

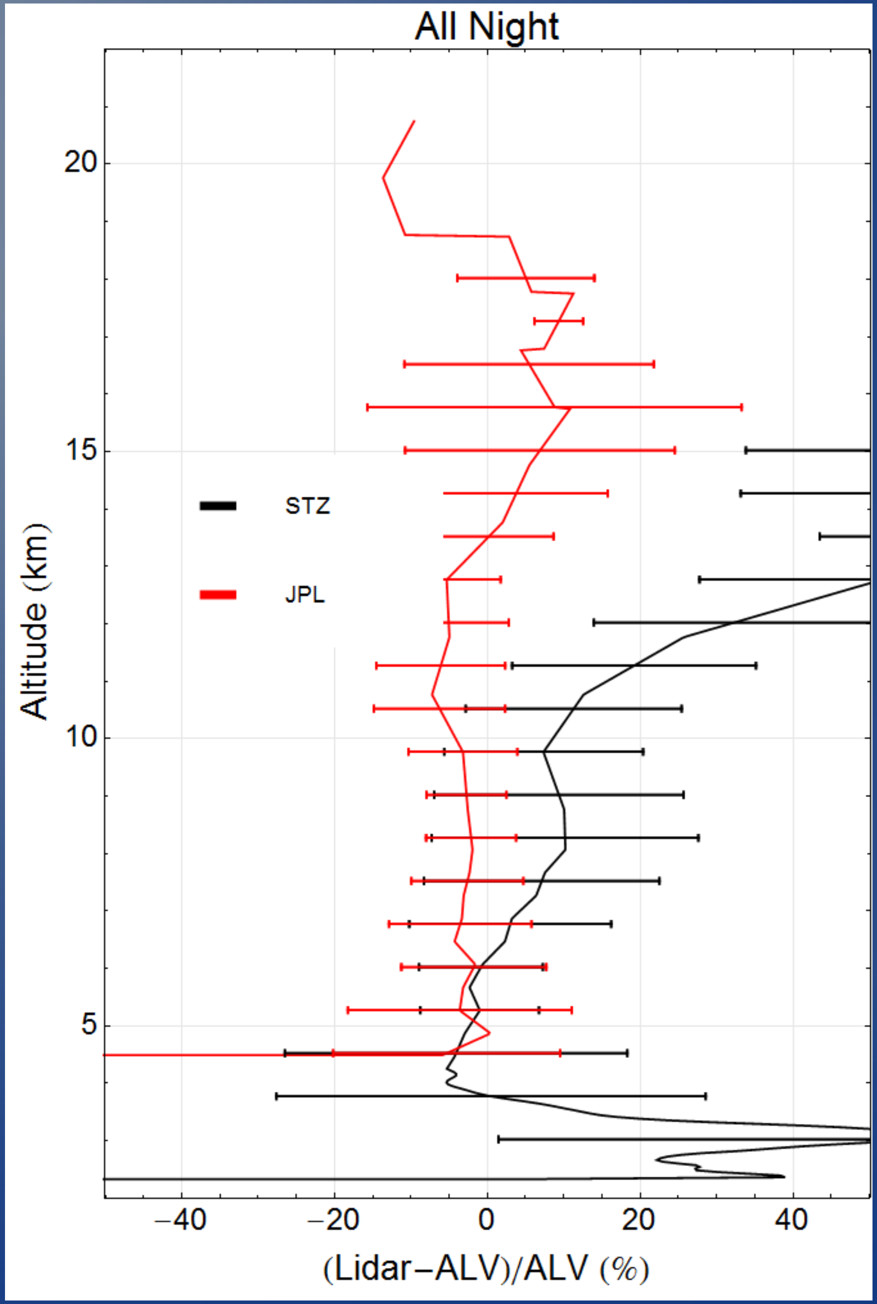


Mean Profiles during MOHAVE

- Mean FP, MLS, ALV, JPL profiles show good agreement in UT/LS
- But ... Resolution is not the same for the instruments shown here!

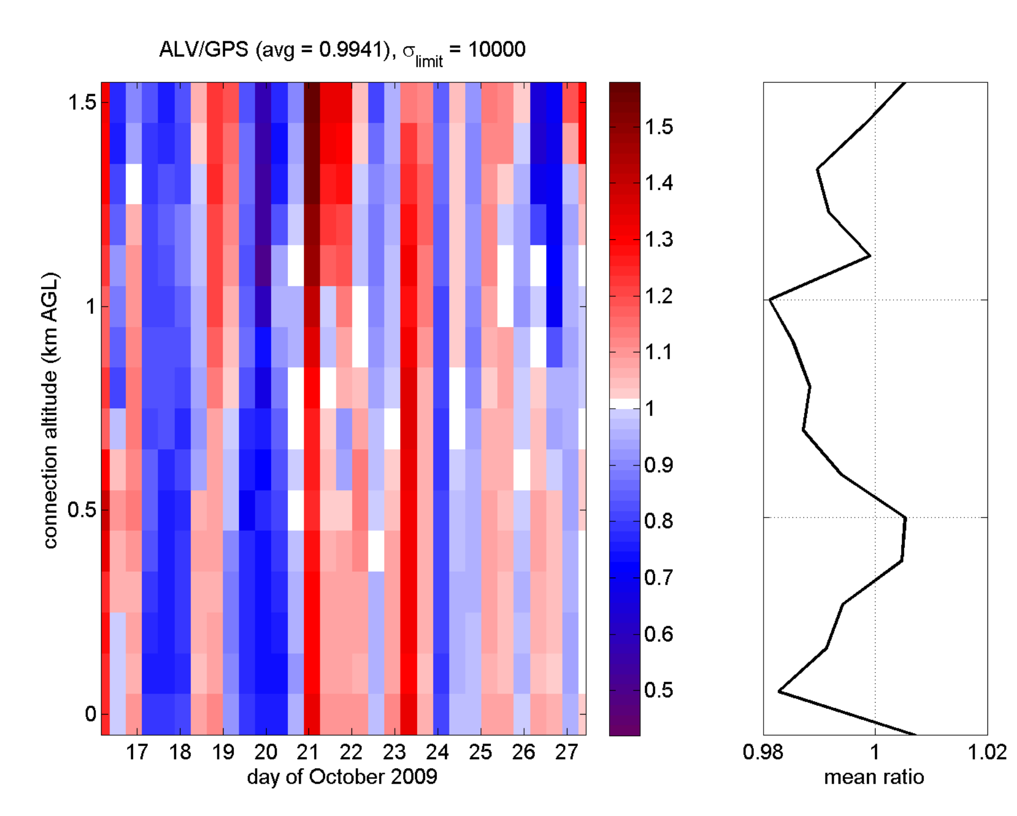


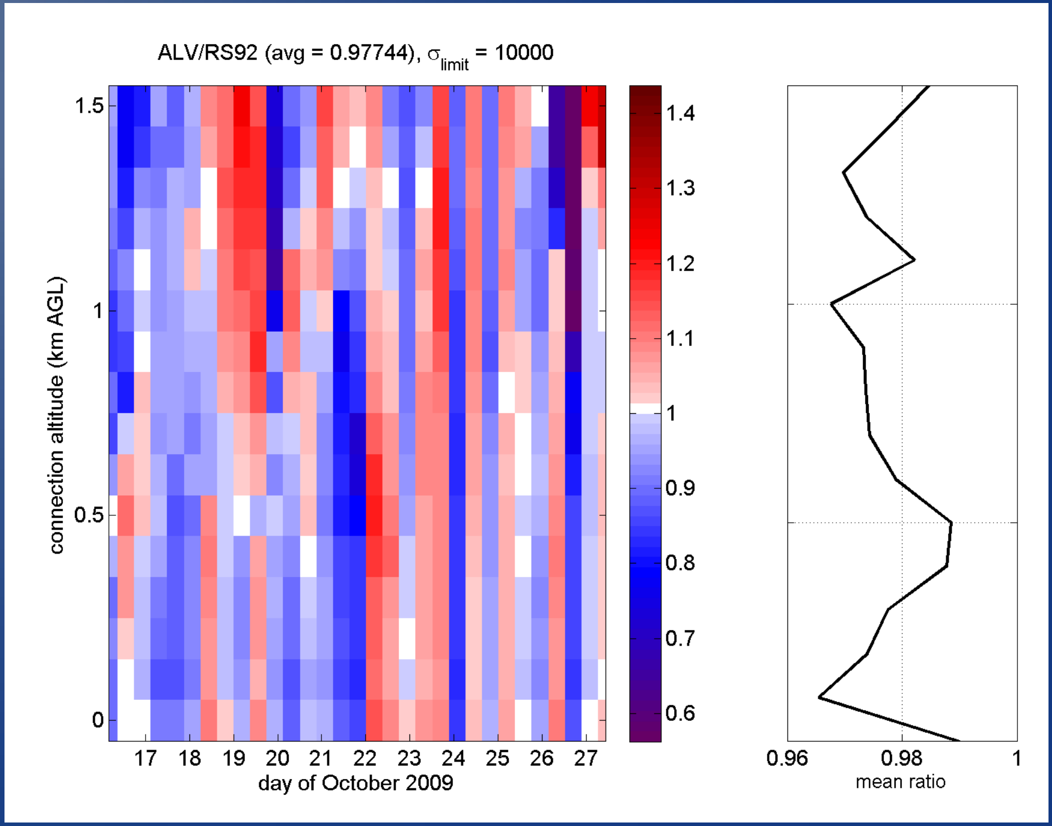
Lidar to Lidar water vapor comparisons



IPW Studies

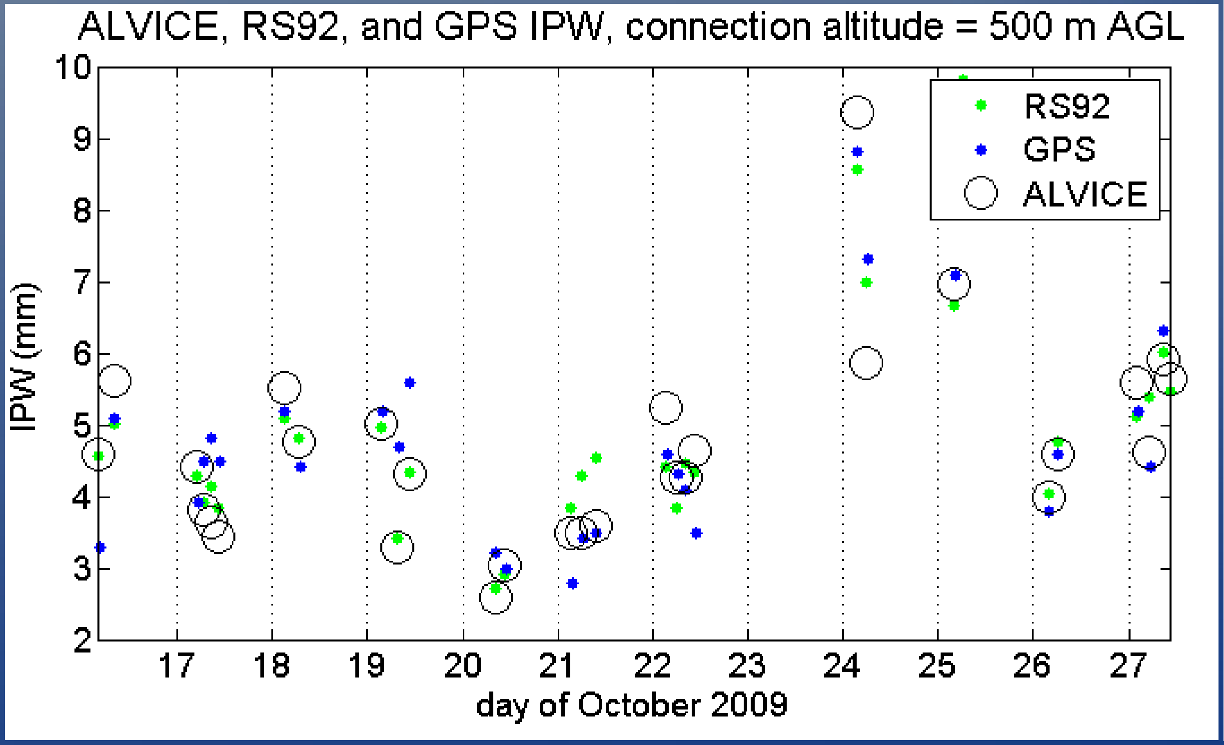
- Consider the influence of different attachment heights on the IPW comparison
  - Use THRef (T, RH) and Suomi (P adjusted to ground) for ground mixing ratio.

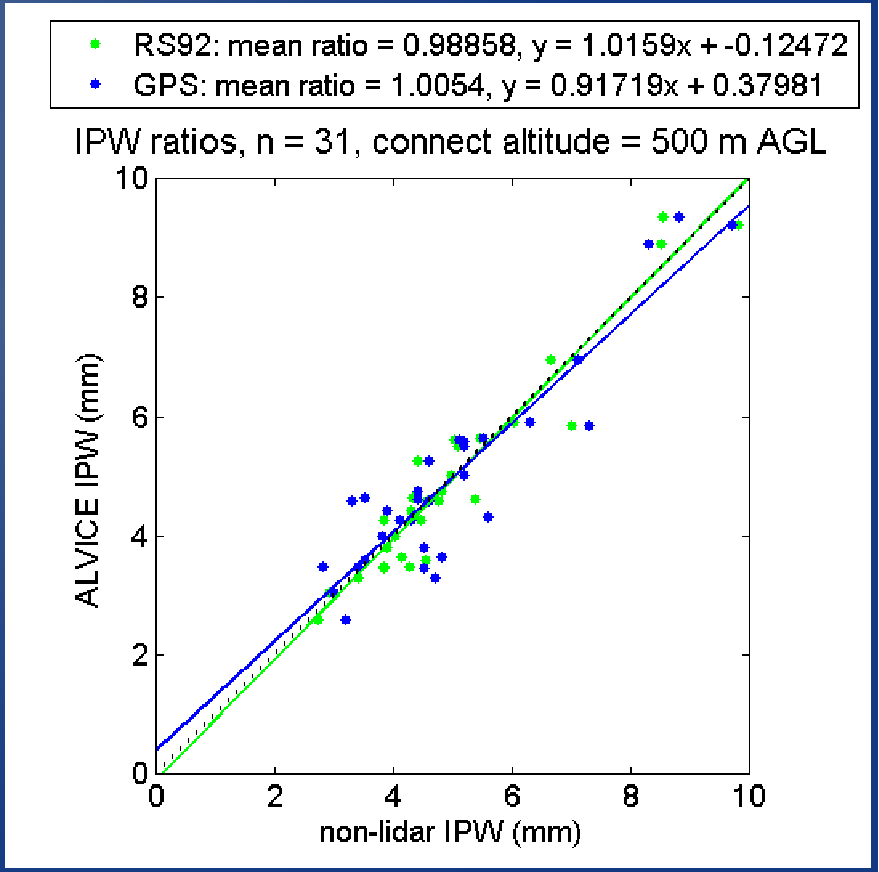




IPW Studies - II

- Consider 500 m as the attachment height
  - Time series and regression both show significant variability
- Will use more stable conditions at HUBC to study adaptive overlap correction technique





Rotation Raman Temperature Analysis

- Use Stokes band of pure rotational Raman scattering at ~355 nm to derive temperature
- New addition to ALVICE
  - Consider linear and quadratic models
  - Quantify bias and RMS
  - Case study

Measurement of Atmospheric Temperature Profiles by Raman Backscatter[1]

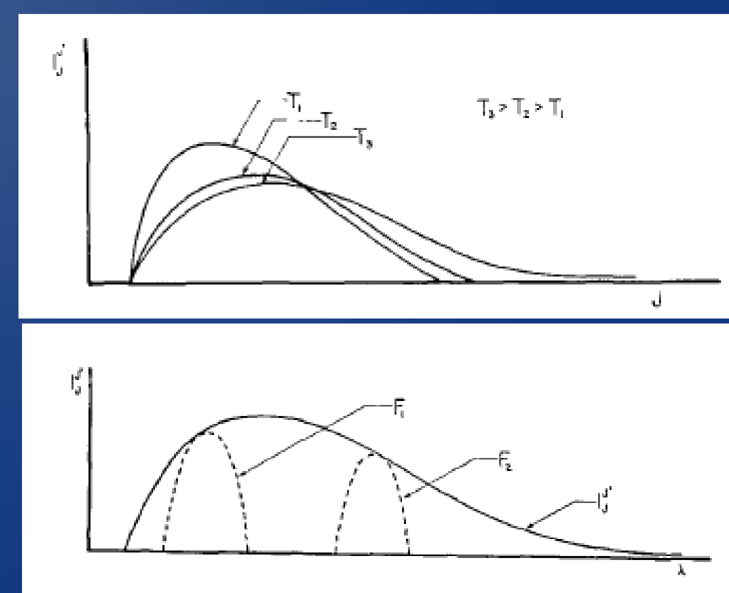
JOHN COONEY

Physics Dept., Drexel University, Philadelphia, Pa. 19104

(Manuscript received 24 July 1971, in revised form 6 October 1971)

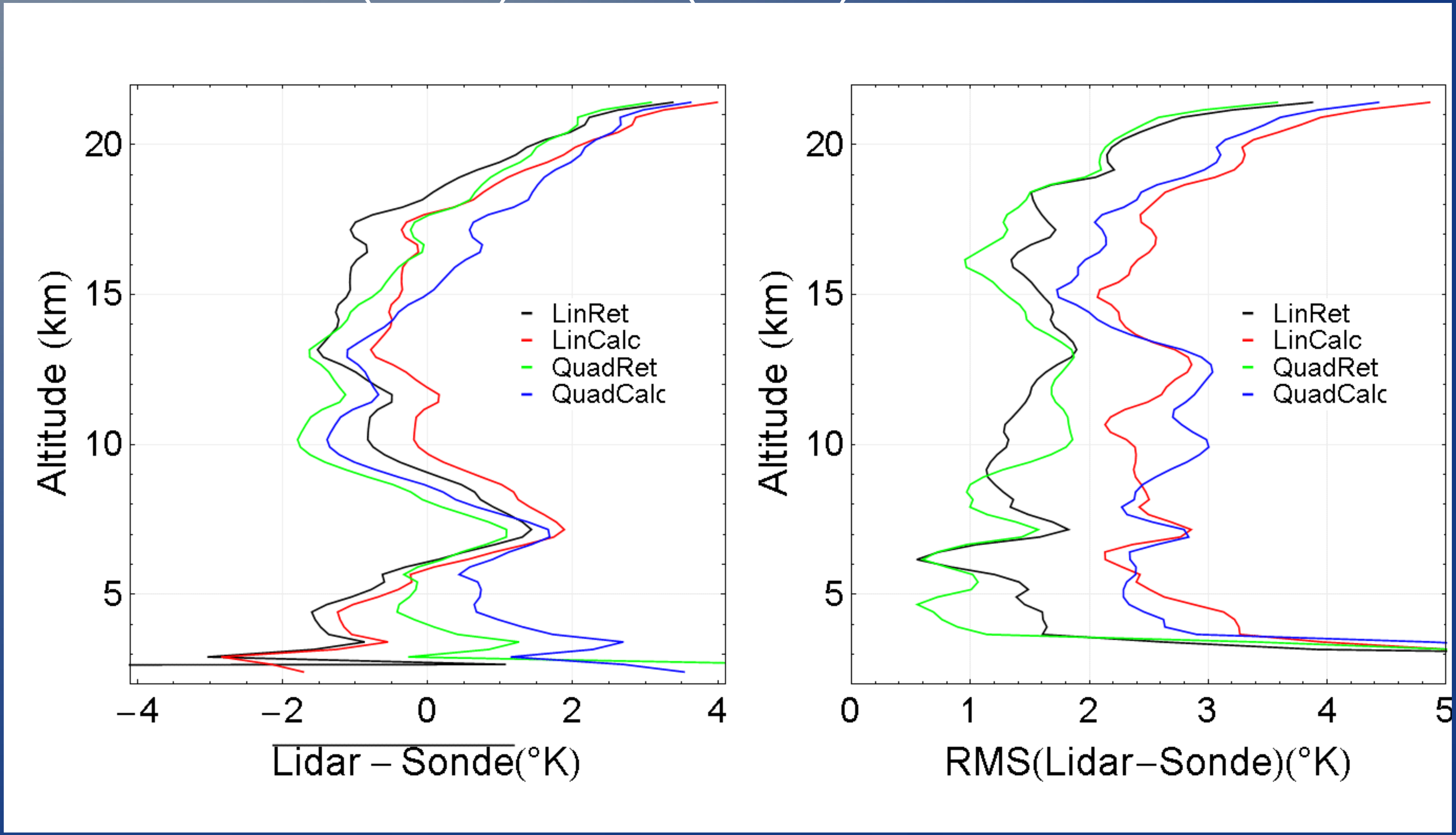
ABSTRACT

A technique for measuring instantaneous atmospheric temperature profiles is given. Utilizing the portion of the laser backscatter arising from the Raman rotational spectrum of N_2, profiles up to 2 km with 100 m depth resolution provide temperature to within a degree with signal-to-noise ratios of order unity. Examples are given.



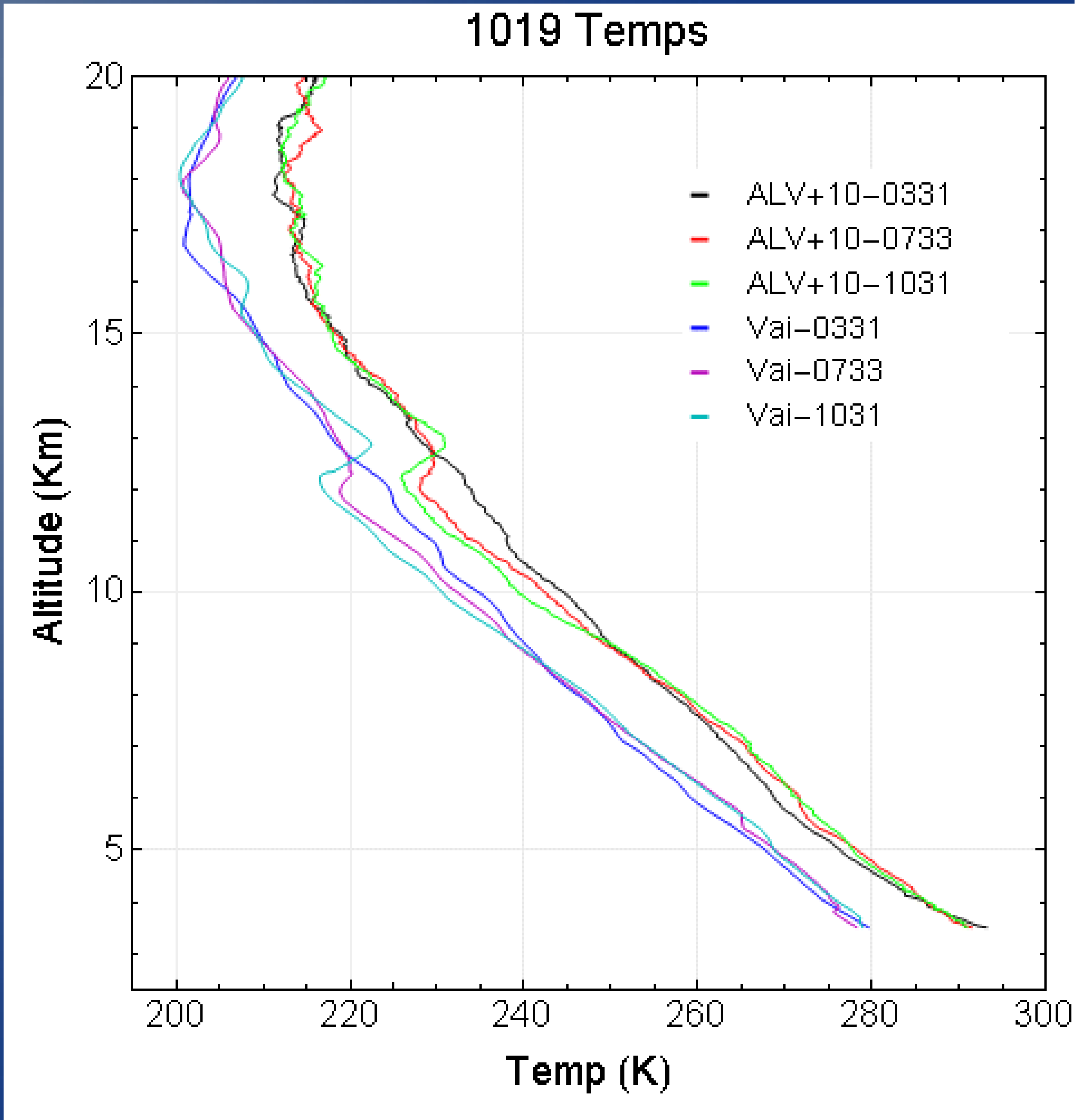
RR Temp Study

- Ret refers to fits to the individual sondes
- Calc refers to calculations based on a global set of coefficients
- RMS of Ret (1-2K), Calc (2-3 K)

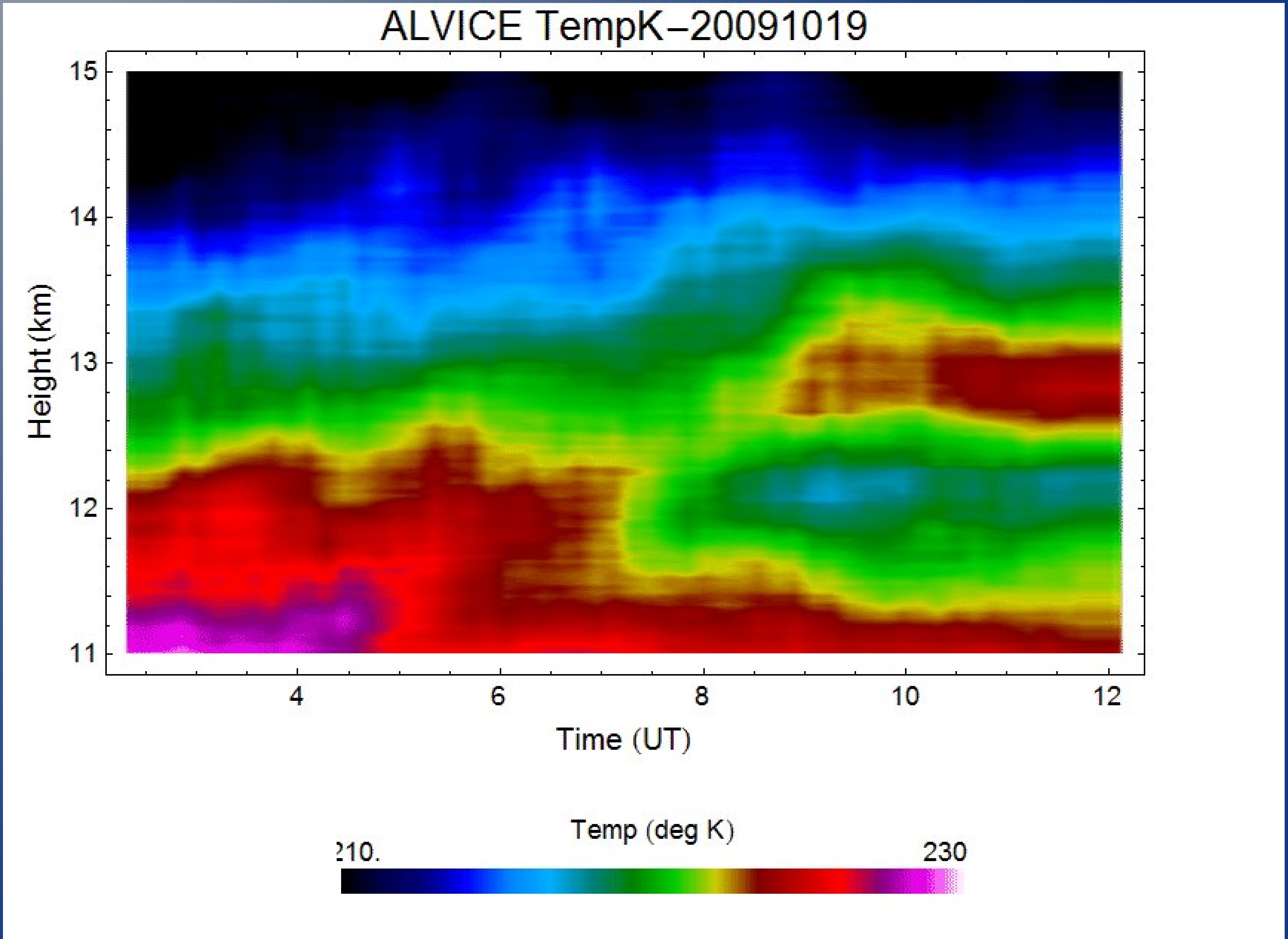


RRTemp Example 1019

- RMS statistics not so good but sensitivity to relative temperature changes permits evolution in atmospheric features to be studied

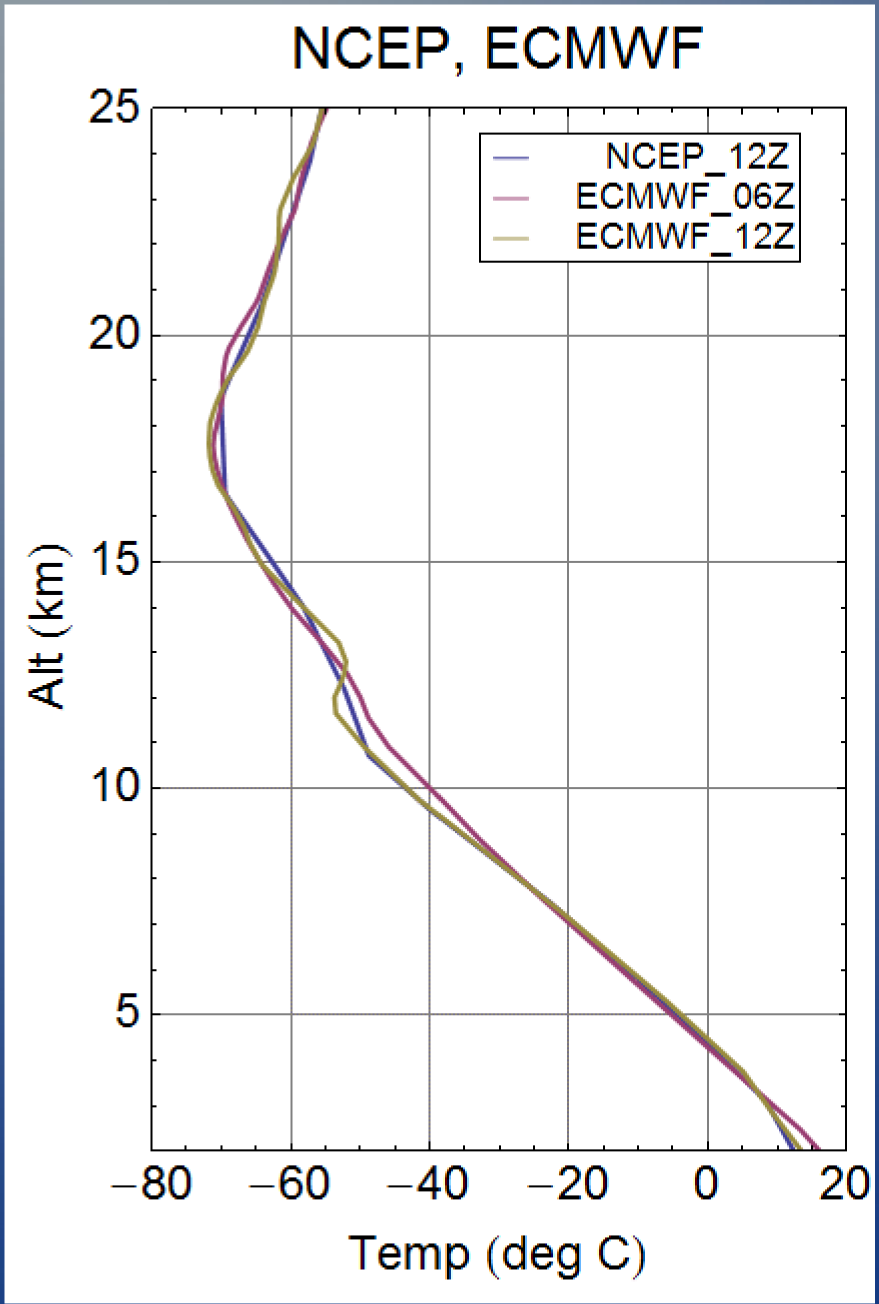


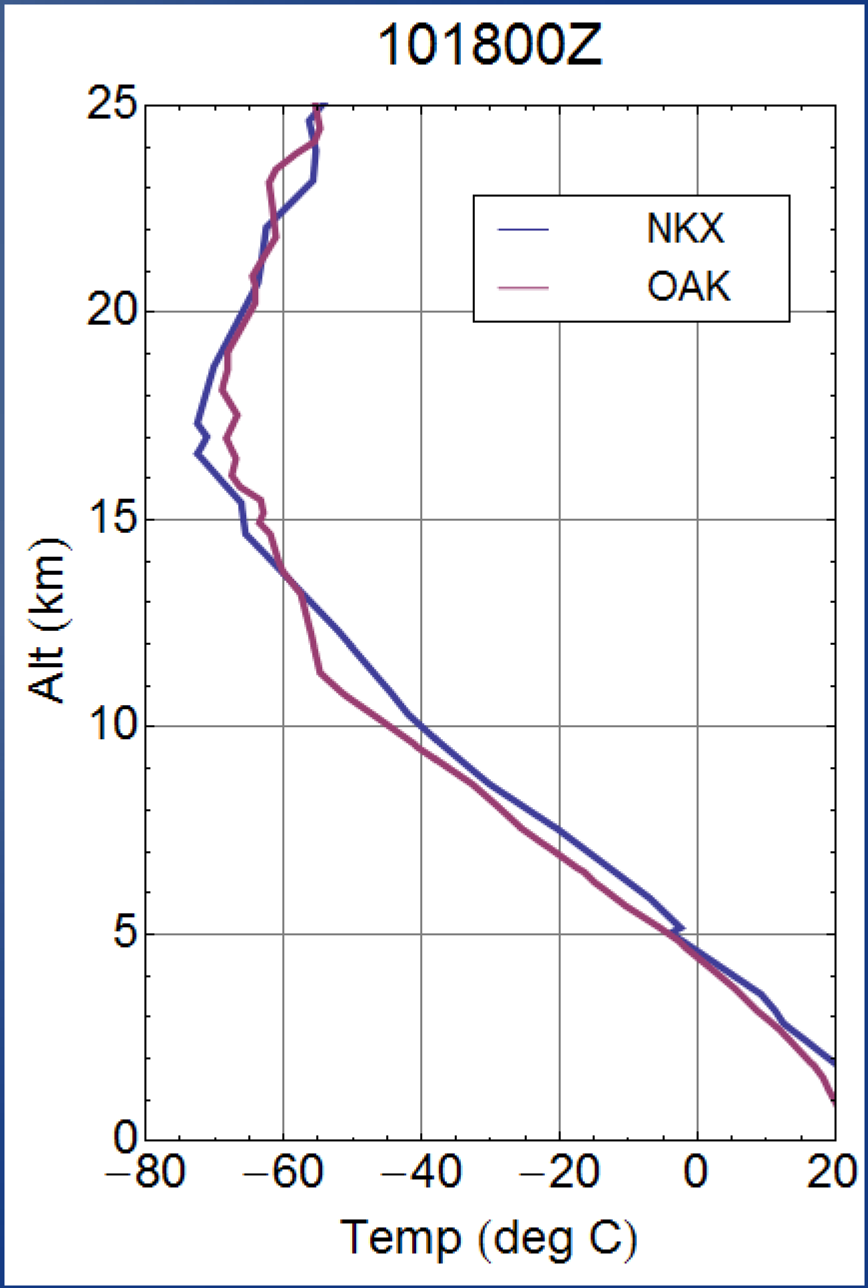
Temperature during SI event on 10/19



Models and Sondes

- ECMWF captures some of inversion. NCEP does not





What's to come

- V1.0 release of temperature retrievals
  - Consider overlap and bias corrections to temperature retrievals before v1.0 release
  - Create time series data of other interesting MOHAVE cases
- Hardware improvements for RR measurements prior to NWAVES_2011 to (hopefully) improve bias and RMS

Cloud Studies

- Some interesting cirrus cases occurred during MOHAVE2009
- Night of Oct 27 permitted retrievals (or estimates) of various cloud parameters
- Measurements based on combination of the direct backscatter, Raman scattering from nitrogen and ice.

A new way to measure cirrus cloud ice water content by using ice Raman scatter with Raman lidar

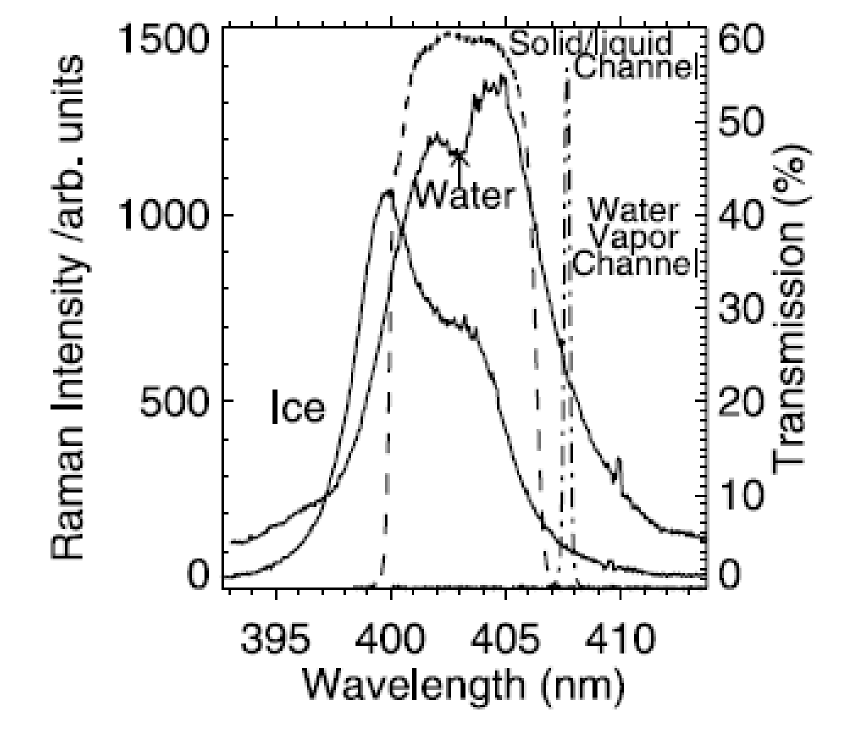
Zhien Wang
Goddard Earth Sciences and Technology (GEST) Center, University of Maryland Baltimore County, Baltimore, Maryland, USA

Mesoscale Atmospheric Processes Branch, NASA/GSFC, Greenbelt, Maryland, USA

David N. Whiteman and Belay B. Demoz
Mesoscale Atmospheric Processes Branch, NASA/GSFC, Greenbelt, Maryland, USA

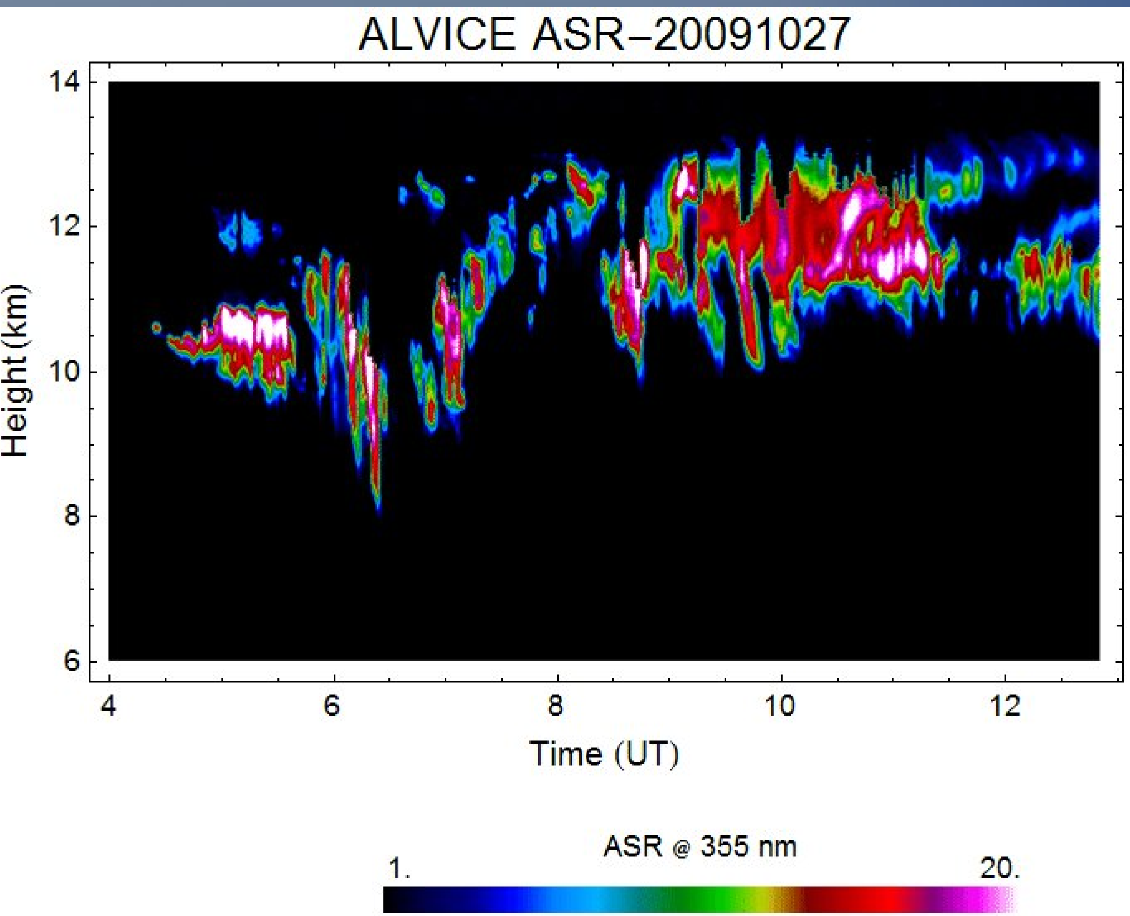
Igor Veselovskii
Goddard Earth Sciences and Technology (GEST) Center, University of Maryland Baltimore County, Baltimore, Maryland, USA

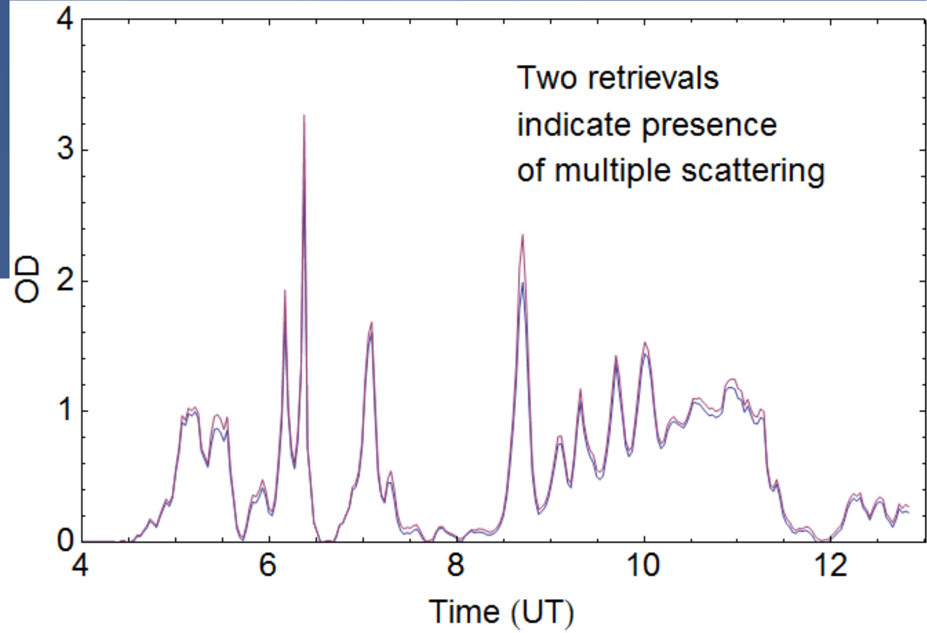
GRL, 2004

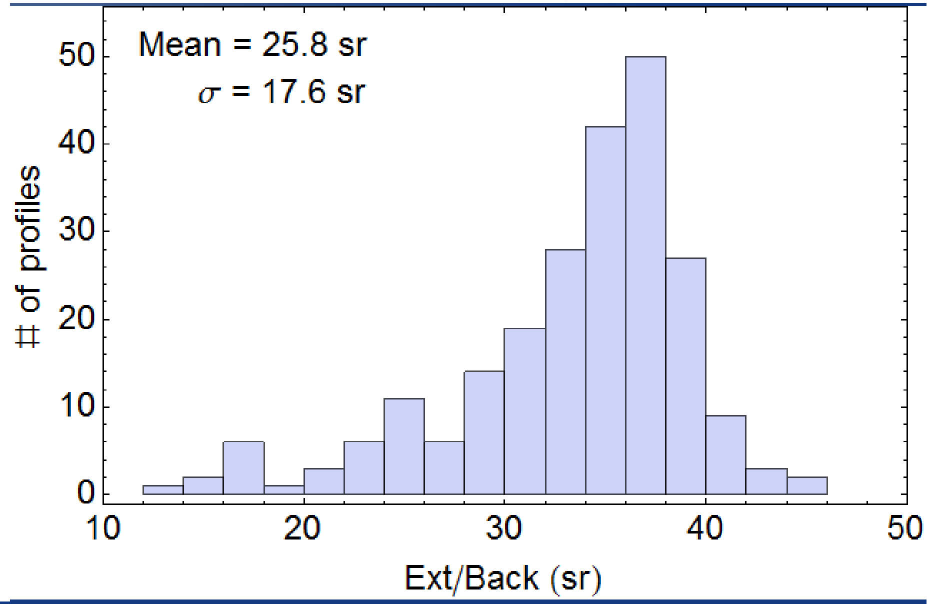


Cirrus on October 27

- Cirrus parameters important for space based lidar retrievals
  - OD, Lidar Ratio
    (assymetrical distribution could be indication of specular reflection)

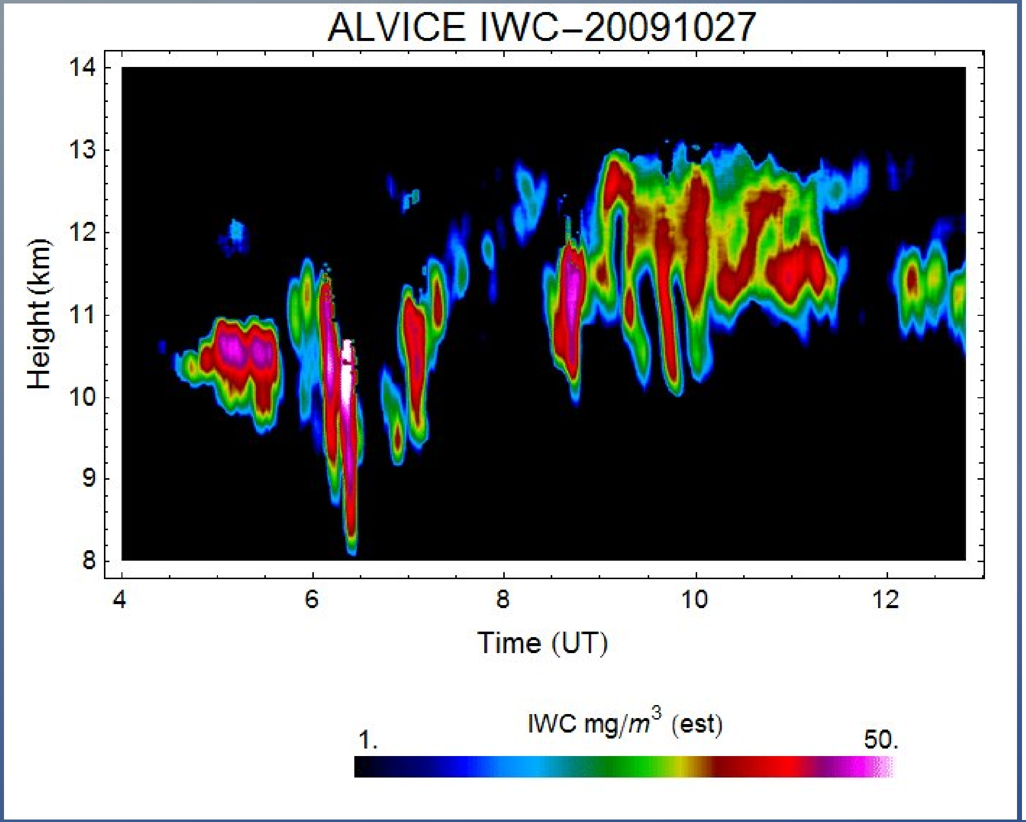


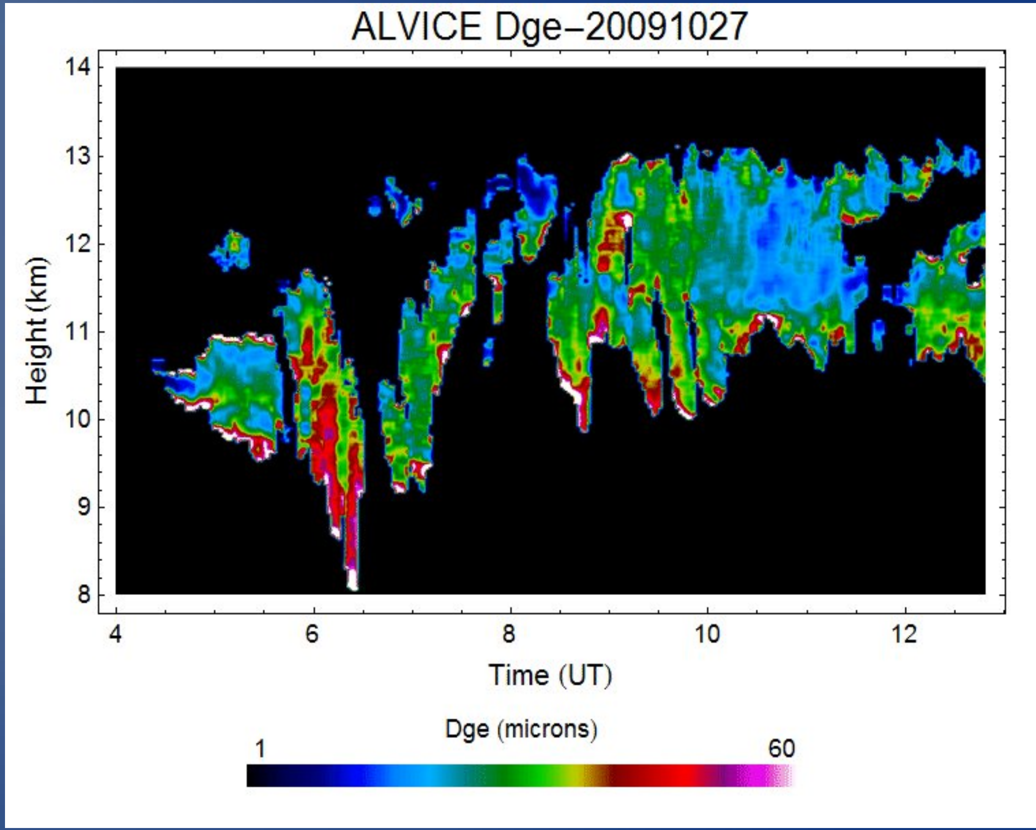




Cirrus on October 27 - II

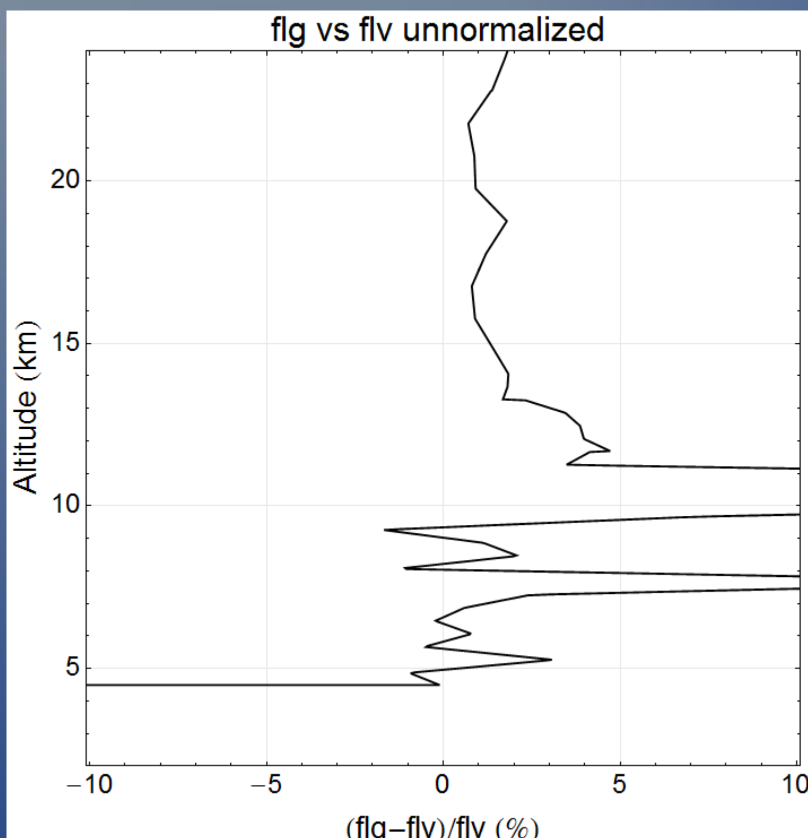
- Ice water content (mg/m^3) and Generalized particle diameter estimates

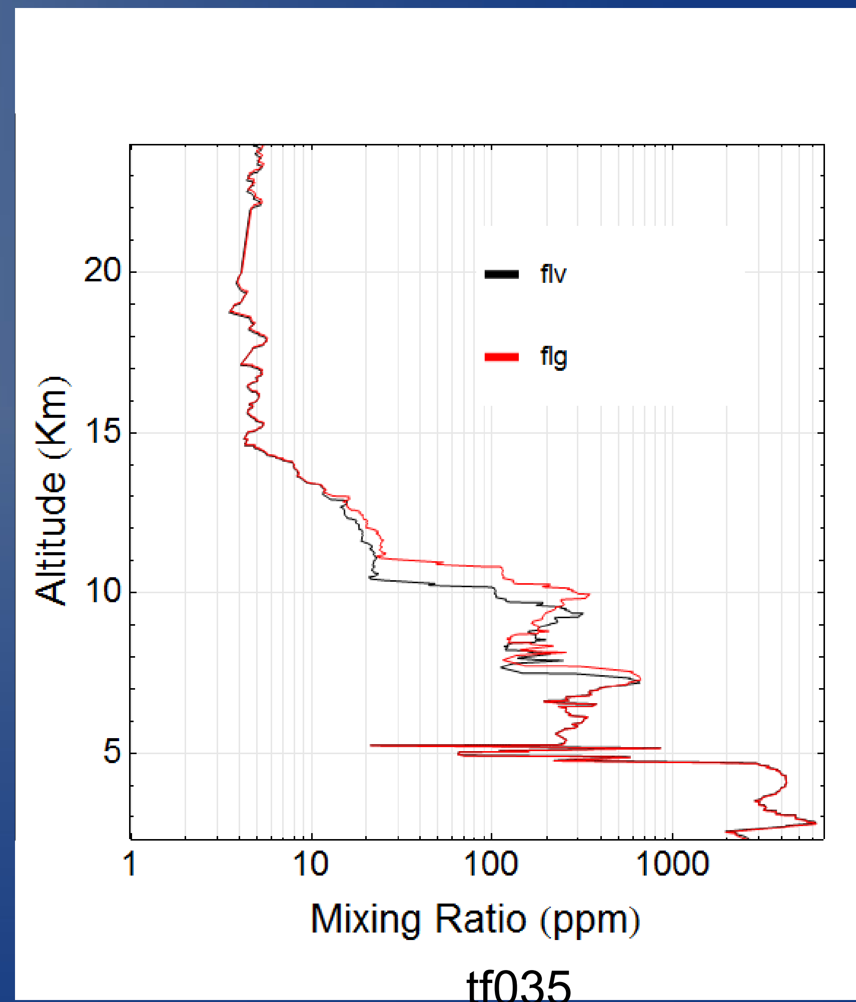




CFH v2 processing (flg vs flv)

- flg uses correction to iMet data
- flv uses rs92 data





Summary

- Comparison of JPL, ALV, FP MLS sensors encouraging but ...
  - Need raw lidar data (as was done in M-II) and discussion of resolution before final comparisons
  - Expect ALVICE v2.0 water vapor by end of year
- Temperature retrievals currently at v0.9. V1.0 expected by end of year
  - Overlap and bias corrections possible
  - Time series analysis of additional cases beyond 10/19
- Further cloud studies for cases of interest during MOHAVE_2009